mKETs-PL working document

Country Report South Korea

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- Technology Partners Foundation
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List of Acronyms:

AICT	Advanced Institutes of Convergence Technologies
CERN	European Laboratory for Particle Physics
e.g.	exempli gratia (for example)
etc.	et cetera
EU	European Union
KEIT	Korea Evaluation Institute of Industrial Technology
KET	Key Enabling Technology
KETs	Key Enabling Technologies
KIAT	Korean Institute for Advancement of Technology
KICET	Korea Institute of Ceramic Engineering and Technology
KOTEC / KIBO	Korean Technology Finance Corporation
KRW	Korean Won (Korean Currency)
MAE	Maps for Advance Era
MEST	Ministry of Education, Science and Technology
MOSF	Ministry of Strategy and Finance
NMP	Nanosciences, Materials and Production
NSTC	National Science and Technology Commission
PL	Pilot Line
R&D	Research and Development
RIS	Regional Innovation Systems
ROE	Rate of Operation and Efficiency
S&T	Science and Technology
SBC	Small and Medium Business Corporation
SMBA	Small and Medium Business Administration
SME	Small and Medium size Company
WTO	World Trade Organization

1. Policy perspective

This report deals with observations and considerations about KETs and PL, their respective effects and policy.

1.1. Country specific innovation system with emphasis on KET

South Korea used to have an authoritarian political model. There are strong and direct bonds between state and industry, including substantial credit opportunities and selective supplementary aid to the big conglomerates (called "*Chaebols*"), import restrictions, strong state encouragement for investment savings and subsidized import of raw materials. In 1987 with the support of new democratic political reforms the stage of economic advancement was finally met. Ten years later and after the Asian Financial Crisis in 1997 the Korean government strongly encouraged the development of a variety of high-tech products and funded many scientific research projects.[i] In the last decade Korea's policy changed from a "catch up" to a "creative innovation system" and is continuing to promote applied research in high-tech and emerging technologies. In order to support the "Pull of Big Science" the government developed a five-year Science and Technology Basic Plan under President Lee Myung-bak (2005 to 2012). The idea behind this plan was to support R&D areas such as basic science, fundamental technologies, and large scale technologies with long-term plans by the government and to let Korea become an S&T power-nation, over 570 initiatives helped that hope.[ii]

In the end of 2012, President Park Geun-hye was elected as the new President of Republic of Korea. For the next five years the administration created a super-ministry called, "Ministry of Science, ICT and Future Planning" that will be mainly in charge of science, information and communications. This is supposed to aid Korea's journey in becoming a leader in innovation-based growth. Therefore one should be aware that changes in responsibilities concerning R&D and innovations might occur after the time of this report.[iii]

Generally Korea uses a variety of indirect and direct instruments, like industrial development, tax credits, tax exemption, R&D grants and subsidies, establishment of technology intermediaries and intensifying technology cortication programs to foster national R&D activities. There will be a short introduction to these instruments in this report.

Until recently before introduction of President Park's administration, Korean government had set the focus on three industrial sectors: Green Growth, High Tech Convergence and Knowledge Based Service.[iv] But in fact, Korea's government has prioritised green innovation at the highest level and has set ambitious goals to generate all energy from renewables by 2030 (2.1% by 2012).

Therefore, the government and private companies recently set up the national smart grid project on Jeju Island (large island in the southern part of Korea) to foster international research cooperation for use.[v]
But so far, there is no specific information for PL. For that reason the report focusses on the most important ministries and institutions which impact the R&D-landscape and might indirectly affect PL.
This report will also identify several projects and governmental programs which support the R&D, S&T and innovation systems in Korea.

If we take a look at the innovation support system there have been enormous changes since the Asian Financial Crisis. Nowadays the innovation policy system mainly has to deal with two economic players: the big conglomerates and SMEs. The innovation trend is still driven by the big Chaebols. But they do not want to be influenced by governmental decisions to save their global competitive power. For this reason the government is shifting their attention toward new companies and SMEs to reduce the power of the Chaebols and to foster the green technology growths. Figure 1 gives a good overview of how the SMEs are being supported by different ministries. Within the support system for SMEs the Small and Medium Business Administration (SMBA) and Korean Institute for Advancement of Technology (KIAT) play the main roles.
The most important ministries and institution which support the companies (not just SMEs) and give indirect or direct support for their respective R&D activities are listed below: [vi]

Ministry of Trade, Industry and Energy (MOTIE, 산업통상자원부)

http://www.motie.go.kr/language/eng/index.jsp

The MOTIE is newly established by the Park's government in 2013 based on the previous Ministry of Knowledge Economy(MKE). It is responsible for economic policy in the industrial and energy sectors, and allocates the R&D budget to the applied research(30% of total government R&D budget at the time of MKE in 2011). The ministry also assumes responsibility for trade affairs.

Korean Institute for Advancement of Technology (KIAT, 한국산업기술진흥원)

http://www.kiat.or.kr/

KIAT is a government affiliated organization of MOTIE, and is responsible for international R&D, R&D infrastructure planning and development and policy for the industrial technology sector. KIAT's main task is to support participation in EU R&D network and international programs, like FP7, Eureka, Enterprise Europe Network, etc. It is also the main supporter of SMEs.

KIAT is running following four programs to forge commercialization of technology[vii]:

1. Industry convergence development project (산업융합기반구축사업)

- Expansion of infrastructure to set up an innovation system and to improve technology development efficiency (3-5 years from 2012).
- Support in form of contribution for building the infrastructure and joint development in industry-academic cooperation or independent development in an institution (depends on the proposed project plans).
- Adjustment of project expenses and support for next year after annual valuation.

2. Development of the growth engine (성장동력기반구축사업)

- Establishment and convergence of Industrial Technology Foundation, innovation in productivity.
- Support for the foundation construction of research and innovative manufacturing, improvement of industrial competitiveness (within five years from 2012).
- Support for projects related to establishment of various foundations and technology development

3. Establishment of materials solutions center (소재종합센터 구축사업)

-Establishment and operation of Test Beds and materials solutions centres.

4. Strategy establishment for emerging technologies (미래유망 산업기술 전략수립 사업)

- Medium and long-term strategy establishment for industrial R&D policy by predicting industry and technology trends from 2012.
- Industrial technology roadmap based development of fundamental convergence technology, application of the roadmap in R&D projects, constant sharing of the roadmap with the private sector through MAE (Maps for Advanced Era).

Korea Evaluation Institute of Industrial Technology (KEIT, 한국산업기술평가관리원)

http://www.keit.re.kr/eng/index.do

KEIT is another government affiliated agency of MOTIE, and is concerned with supporting domestic R&D for the industrial sector and Industrial Strategic Technology Development Programs. KEIT's responsibilities are project planning, development of projects, project calls, selection of projects, review by evaluation, monitoring of projects, evaluation and follow-up surveys. Beside this, KEIT is the specialised agency for the management and evaluation of the SME R&D grant programs funded by the Small and Medium Business Administration(see p.7) .

Korea Institute of Energy Technology Evaluation and Planning (KETEP, 한국에너지기술평가원)

http://www.ketep.re.kr/english/index.jsp

KETEP is one of the R&D funding, planning and evaluating agencies for MOTIE. While KEIT and KIAT focus on industrial R&D in overall except for energy topic, KETEP solely takes care of the energy R&D.

Korea Institute for Advancement of Technology (KIAT, 한국산업기술진흥원)

https://www.kiat.or.kr/site/main/index/index002.jsp

KIAT was established in 2009 and is considered as the major New Growth Engine Fund of Korea. KIAT promotes industrial technology innovation and supports innovation-related policy development through project initiation[viii].

Small and Medium Business Administration (SMBA, 중소기업청)

http://eng.smba.go.kr/main.jsp

In 1996, the Small and Medium Business Administration (SMBA) was established as a government department to develop systematic policies and to co-ordinate administration and support for SMEs. In 2011, the R&D support has reached approximately 4.2% of the overall governmental R&D budget.

Small and Medium Business Corporation (SBC, 중소기업진흥공단)

http://www.sbc.or.kr/sbc/eng/main.jsp

SBC provides policy funding for small businesses to support operations, new product development and streamline business structures. The target of this governmental-funded organization is to provide loan services and other support for smaller businesses that possess technologies with commercial potential.

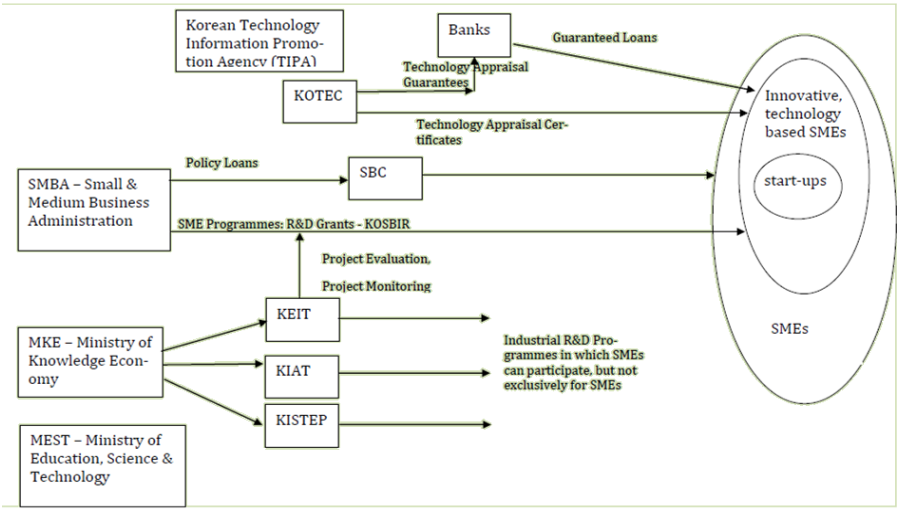
Korean Technology Finance Corporation (KOTEC/KIBO, 기술신용보증기금)

http://www.kotec.or.kr/

As a financial institution KOTEC provides comprehensive services for SMEs and venture enterprises. The major services are technology guarantees, technology appraisals and technological and management support. Since the founding in 1989, KOTEC provided more than USD 167 billion to SMEs, while more than 80% of the total funding was first provided to companies which are focusing on new technologies via the Technology Credit Guarantee System.

As mentioned before, the Korean government invest a lot of R&D activities in SMEs. The support scheme is depicted in Figure 1. The main innovation financing role includes SMBA and smaller ministries of MKE, like KIAT, KISTEP and KEIT which manage the R&D grants and funding. The KOTEC is focusing on loan guarantees for technology based SMEs.

Figure 1: Map of SMEs Innovation Support system in South Korea



Source: South Korea SME Innovation Support Schemes, Final Report on IPF Review visit to South Korea, April 2012[ix]

Ministry of Science, ICT and Future Planning (MSIP, 미래창조과학부)

http://www.msip.go.kr/english/MainMiddle_main.action

The MSIP is responsible for science and technology and ICT and allocates the R&D budget to basic research. In addition, most of Korean government funded research institutes (25 out of 26) are under control of this ministry. Like MOTIE, MSIP has an R&D funding agency, i.e. NRF (National Research Foundation).

National Research Foundation (NRF, 한국연구재단)

http://www.nrf.re.kr/nrf_eng_cms/

Like other R&D funding agencies like KIAT, KEIT and KETEP under MOTIE, NRF does a similar function for MSIP.

KETs in Korea:

The KETs are defined through the governmental plan which is driven by scientific and technological research. There are several initiatives to support the development of specific KETs in Korea. The public sector plays an important role in the promotion of emerging technologies. Currently the government prioritises the following key areas:

1. ***Key industrial technologies*** (e.g. automotive, shipbuilding, machinery and manufacturing, semiconductors, liquid crystal displays, etc.)
2. ***Emerging Industrial technologies*** (e.g. Next-generation system S&W, cancer, diagnosis and treatment, brain science, drug discovery and development technology, etc.)
3. ***Knowledge-based service technologies*** (e.g. software, culture technology and design)
4. ***State-led Technologies*** (e.g. construction, transportation, space and ocean, nuclear power)
5. ***National issues-related technologies*** (e.g. Immune disease and infectious disease response, food safety evaluation, IT nano-device technology,)
6. ***Global issues-related technologies*** (technologies related to energy, climate change, environment and food, etc.)
7. ***Basic and convergent technologies*** (e.g. platform technology development Bio-chip and biosensor, intelligent robot, nanotechnology-based, convergent/composite materials, technologies) [x]

21C Frontier R&D program:

From 1999 on and as a part of South Korea's scientific development strategy, called "Long-term Vision for Science and Technology Development Toward 2025", the government has established the "21C Frontier R&D program". This program supports 23 projects over a 10-year period, developing core technologies that hold commercial potential, including nanotechnology, space technology and bioscience. Each of these projects benefits from funds of at least USD 1 million.[xi] E.g. between 2001 and 2005 the government launched three programs for nano-technological development: National Program for Tera-Level Nano devices, the Centre for Nano Scale Mechatronics and Manufacturing and the Centre for Nanostructured Materials Technology. During the second phase (2006 – 2015) the major R&D efforts will be divided into basic prerequisite activities (2006 – 2010) while system-level technologies that use nanotechnology will be identified and promoted during the second period (2011-2015)[xii].

In 2003 a second research plan, which identified the "Growth Engine Industries for the Future" from biotechnology to semiconductors was introduced by the government. These projects are being funded by up to 50% by public R&D investment. Basic research receives a quarter of the total public spending on R&D.[xiii]

Future Industry Pioneering Technology Development Program

This is the main R&D program managed by the OSP (Office of Strategic R&D Planning), the R&D management body of MOTIE, which aims to create new growth engines that will give big impact on Korea's future industry. The program is divided into two sub-programs which focus on short/mid-term economic results and on creation of new market respectively. Topics of the former include new natural pharmaceuticals, system semiconductors for IT convergent devices, green transportation system based on next generation electro-vehicle, high efficient large area thin film photovoltaic and "K-MEG" (Korea-Micro Energy Grid). The latter includes topics like transparent flexible display, offshore plant for producing deep sea resources, high-precision

roll-to-roll production system for printed-electronics, multifunctional grapheme materials and components and wellness human-care platform.[XXIII]

Techno Parks[xiv]:

The Seoul metropolitan area is the focus of much S&T and innovation activity. As a result of this development regional growth is rather unbalanced. Hence, the government has introduced a number of schemes over the years. In 2010 Korea had 105 regional innovation centres and 18 Techno Parks as well as seven programs to strengthen the competitiveness of industrial cluster programs. Research projects are being performed in all sectors like universities, various basic researches, and industry.[xv]

The Techno Parks in Korea promote regional industries and Regional Innovation Systems (RIS).

The following three projects offer a variety programmes. Since 2012 each Techno Park promotes these projects.

1. ***Leading Industry Promotion Project in Economic Regions (광역경제권 선도산업 육성사업)***
   Select two leading industry projects in each province and support and promote these projects.
2. ***Promotion Project for Regional Strategic Industry (지역전략산업 육성사업)***
   The government focuses on this project to boost competitiveness of regional industry reflecting regional characteristic through enterprise support service, establishment of innovation centres, etc..
3. ***Promotion Project for Regional Special Industry (지역특화산업 육성사업)***
   This project tries to Regional Innovation System (RIS) and improves regional innovation capacity through establishment of regional innovation centres, research institutes and networks.

Relation to EU:

Recently, the EU and Korea decided to identify main priorities for enhanced cooperation and establish new activities in five research fields:

1. **Energy (Non-Nuclear):** The EU (with Europe 2020) and Korea (with Green Growth) share under the SETPLAN the need to reduce CO2 emissions and improve energy efficiency. Therefore stakeholders like MKE-KIAT/KETEP, MEST from ministries and related agencies are involved.
2. **Nano sciences, Materials and Production (NMP**). To become a key leader in this area, Korea and EU agreed to launch a workshop in 2012 (February, March).
3. **Information and Communication Technologies**: Korea is participating in different areas of the EU Research program on ICT. Main topics are Future and Emerging Technologies, Future Internet and Robotics to grapheme technologies.
4. **Researchers Mobility**: Cooperation between Korea and EU in this field should be intensified. The role of National Contact point functions and their relevance for MKE and MEST are up to discussion.
5. **International Cooperation**: In 2008, KORANET organised the first joint call to publish joint funding research programs from Austria, France, Germany, Korea and Turkey to develop a report about S&T cooperation. [xvi]

In 2006 South Korea has signed an agreement with the European Laboratory for Particle Physics (CERN) to address ambitious basic science initiatives. Korea also formed several bilateral S&T agreements with other EU member states. The latest agreement took place in May 2012 with Denmark, and is referred to as the “Green Alliance” to support and participate on research programs in the green sector. So far South Korea is the only Asian country which signed both, the Free Trade Agreement and an S&T Agreement. In the future new trade and research opportunities in the area of automotive products, electronics, pharmaceutical goods and medical devices are being expected.

It is important to mention that Korea is also a member of the World Trade Organization (WTO), which set several rules and agreements on how to support R&D activities. These regulations influence PL indirectly. The WTO seems to have regulated R&D and business activities. We assume that these agreements indirectly influence PL.[xvii]

For future research and EU-Korea S&T collaborations several issues still need to be addressed, especially the lack of transparency and unwillingness to share information on the Korean side state a big problem[xviii]

To summarize and highlight the main messages of the above, please refer to the following.

- The government innovation policy mainly addresses SMEs, meaning the *Chaebols* are playing their own music
- While the innovation blueprint for the new Korean government isn't clear yet, the report deals with several representing innovation programs from the past governments, and infers top priority technologies the Korean government has been pushing for the innovation
- Main stakeholders of the Korean innovation under the new Pres. Park's administration are the Ministry of Science, ICT and Future Planning, the Ministry of Trade, Industry and Energy and their R&D planning/evaluation agencies such as NRF, KEIT, KIAT and KETEP (latest overview after the ministry restructuring 2013)
- Three representing innovation programs that aim for future market generation and R&D,B cluster were introduced.
- Top priority technologies one can derive from the innovation programs and their relation to EU KETs involve topics like energy (non-nuclear), nano science/materials/production and ICT.

1.2. Organisation of multi-KETs policy

The National Science and Technology Commission (NSTC) and Advanced Institutes of Convergence Technologies (AICT are the main forces behind multi-KETs match making programs. Science and Technology policies are being formulated by the NSTC. In order to develop the basic S/T-Plan the commission beforehand develops an S&T-forecast and long-term S&T-development visions. According to these guidelines South Korean government plans the further steps. To our best knowledge there is no sign for the use of the term multi-KET.
2008 was the founding year of the AICT, a research center specialized in the field of convergence technology research. Being one of the seven major industrial sectors this can be seen as a showcase of active S&T-policy.

National Science and Technology Commission (NSTC, 국가과학기술위원회)

http://www.nstc.go.kr/eng/

NSTC focusses on the formulation of S&T policies.

1. S&T-Forecast:

- Done by analyzing trends in S&T
- Technologies that are likely to stimulate further growth
- Timing of emerging techs and Korea's capabilities for growth in these technolgies
- Done every five years with a 25 years projection

2. Long-term S&T development:

- Development of long-term visions for selected target-technologies
- Outlining a strategy for these target-technologies
- Done every five years with a 25 year projection

3. Basic S&T-plan:

- Definition of S&T-development goals according to S&T-forecast and long-term vision
- Formulation of concrete policy programs to realize said goals
- Done every five years w/a five year projection[xix]

Advanced Institutes of Convergence Technologies (AICT, 차세대융합기술연구원)

http://aict.snu.ac.kr/eng/

Known as "World leader in convergence technology research".

1. Four Major functions:

- Research of convergence technology and application of research performances
- Training experts of convergence technology and events for promotion of convergence technology
- General supports to establish a business related to convergence technology
- International and domestic collaboration for convergence technology

2. Institutes for Convergence:

- Institute of Nano Convergence
- Institute of Bio Convergence
- Institute for Smart System
- Institute of Transdisciplinary Studies

1.3. Main policies for Pilot Activities

There are no major policies directly aimed towards PL in South Korea. We assume that WTO agreements might indirectly influence PL. Nevertheless there are four different institutes which support PL indirectly and were mentioned by our interview partners.

Korea Institute of Materials Science (KIMS, 재료연구소)

http://www.kims.re.kr/eng/

As a government funded research institute KIMS facilitates R&D, test and evaluation and provides technical support related to material technologies in order to promote innovative technology and industrial development.

KIMS is acting as a hub for material convergences and processing technology, metallurgy and processing technology, authorization and certification of components, ceramics, processing technology, surface related materials and processing technology.

Korea Research Institute of Chemical Technology (KRICT, 한국화학연구원)

http://www.krict.re.kr/english/index.php

KRICT seeks to improve the competitiveness of the chemical industry and to promote the establishment of new national scale industries by developing and disseminating original chemical technologies and relevant convergence technologies. Furthermore they manage the public chemical technology infrastructure.

Korea Institute of Ceramic Engineering and Technology (KICET, 한국세라믹기술원)

http://www.kicet.re.kr/

KICET has been the driving force behind the success of Korea's ceramic industry as a government-sponsored entity, providing the industry with R&D assistance related to research and development in the field of ceramic technology, testing, analysis/evaluation of ceramic raw materials and products and technology support for businesses in ceramic-related industry.

Electronics and Telecommunications Research Institute (ETRI, 한국전자통신연구원)

http://www.etri.re.kr/eng/

Their main function is training professionals in the fields of science and technology, providing technical consultancy and technical information, cooperating with domestic and foreign institutions and supporting and developing convergence technologies. ETRI is partitioned into the divisions IT Convergence Technology, Component & Materials Research Laboratory, Broadcasting & Telecommunications Media Research Laboratory, Communication & Internet Research Laboratory, Software Research Laboratory, Creative Content Research Laboratory, Creative Future Research Laboratory and Strategy & Planning Division.

Basically, there are several PL programs with different regulations set by the respective institution. The Korean government is funding 3 RTOs– Korea Research Institute of Chemical Technology (KRICT, 한국화학연구원), Korea Institute of Ceramic Engineering and Technology (KICET, 한국세라믹기술원), the Korea Institute of Materials Science (KIMS, 재료연구원) –, in order to establish PL for a public use on their sites, for the respective industry sectors (chemistry, ceramic and material). The first project term runs from July 2010 to June 2013 and guarantees the purchase of the required equipment. The second term, another three years, will be funded with around 6 billion KRW for each RTO, and will provide properly working PL according to the visiting

companies' demand. Even though there is no deadline, each PL is supposed to be financially independent eventually.

In the ceramic area PL is known as a Ceramic Test Bed. The Ceramic Test Bed can be used by several companies to test their prototypes. Some companies do not have a PL available and therefore have to stop the production line, this is expensive and time-consuming though. The public initiatives define the Ceramic Test Bed as a good test opportunity for the companies – especially for SMEs. Public Institution (e.g. KICET) establishes, maintains, and manages the PL. Korean companies may use it after paying a fee.

Especially SME find the use of public PL reasonable. The bigger companies get supported with land and tax incentives by the regional government. This requires a lot of political effort. The financial support differs from regional government to regional government and between governmental programs..

2. Business perspective

2.1. Implementation of multi-KETs pilot lines

The most important arguments for using a PL is obviously that companies or the customers of companies are able to test the mass-production feasibility in order to minimize risks concerning quality management. In case of a new technology, an adjustment of the PL might lead to a swift evaluation of the new developed tech. When we compared the costs of installing a PL to the installation of a mass production line PL turned out to be between 10 and 100 times cheaper than the mass production line. Companies can receive monetary funding through government-funded projects. The Ceramic Test Bed of KICET for example, can also be used as a production line, so that companies, especially SMEs might also use the facility as an actual production line. User might their application in the PL and if technical problems occur KICET as an institute can support the companies with technical development and consulting expertise.

The main drivers initiating a (multi-KETs) PL are the companies themselves and the government. Some R&D programs are driven by a governmental plan (e.g. the government has set ambitious goals to reduce CO2 emissions by 30% from the anticipated "business as usual" levels in 2020)[xx]. In this case the PL is being financed by both the national government and private companies. The government funded projects are a big support for all R&D centres that develop PL. If economic feasibility is given, there is a downstream industry available, results of the R&D activities look promising by the eyes of customers and technical maturity is reached transition to mass production might be possible without needing another pilot production phase (pilot production might still be necessary when the R&D results are not 100% ready for the mass production). Developing a new product without a downstream industry will need heavy support by the government in order to establish a suitable downstream industry and the necessary business infrastructure for the market.

There are several issues regarding the usage of external PL: big companies might fear problems with confidentiality. Being independent from government policies is also a reason to avoid public PL. In order to provide us with an insight an interviewee working at one of Korea's big companies formulated nine steps that are usually required to develop a product, starting at the initial idea development and ending with mass production. In order to move forward to the next step the all previous steps have to be finished: The first step is always the generation of new ideas. This typically involves researchers and engineers who propose possible technical innovations (bottom-up approach) followed by a very thorough selection ("cold eye view") of the proposed ideas. Some of the important parameters for choosing or neglecting an idea might be an economic estimation of production costs, the potential market situation and the amount of potential sales. In order for the PL to become and added asset the company needs to be sure that the PL will eventually be part of an mass production line. E.g. logistic functions might be handled through manual labor during the PL-phase and easily substituted by automated routines when it comes to mass production. This will obviously increase productivity. Another example for an integrated PL-approach might the production of a lot of items in order to satisfy future demands. Even though in this case the market is not yet fully established it still might evolve to become attractive for bigger companies.
The implementation of (multi-KET-) PL differs in the use of an own PL or public PL.
Companies usually do not have quantitative conditions or standards as a basis for deciding whether or not to establish their own PL, it is rather a matter of internal discussion (successful prototype might partially influence the decision, though they are no reason themselves). Getting help from consulting companies for such purpose is usually not the best idea in order to get a clear view on the ongoing process. One company implemented so called "stage gates". These function as a basis for decision-making when it comes to the development of new products. The stage gate is divided into nine steps starting at the initial development of an idea and ending with the mass production phase. In order to move forward from on stage-gate to the next step previous steps have to be dealt with in full. The first step is always the creation of ideas which involves proposals of new technical innovations by researchers and engineers (bottom-up approach). This is followed by careful selection ("cold eye view") of the proposed ideas by considering several economic figures such as the economic

estimation of production costs, the potential market situation and potential sales amount (usually at least 10 billion Won). Decision makers have to consider opinions from researchers, field engineers and marketing experts. Naturally each expert has his/her angle on the matter. Researchers are often idealistic and optimistic about the possible results of fundamental research, but oftentimes they only remember the one success that came out of hundreds of failures. This leads to the common belief that success is generally achievable and a blind eye for problems that might occur. Field engineers on the other hand are usually quite conservative when it comes to research results. Therefore they often lack the visionary capabilities of researchers, limiting their ability to spot future. What both researchers and field engineers have in common is that they are product-oriented rather than customer or market oriented, which possibly leads to a disadvantageous ROI (return-on-investment). For this reason, marketing experts are often involved to provide researchers and engineers with the optimal target price, product launching timing, attractive features/functions, etc...
Another factor that should not be overlooked is that the decision maker him/herself might be tempted to commercialize as soon as possible, not only to get recognition of their bosses but also in order to request further funding from upper management. Usually their assignments for such leading positions are for limited time only (under five years) whereas the installation of a PL (two years for concept development, removing unidentified variables during designing phase and running) and a mass production line (another two years) requires several years to create high-quality products for the market. There is a high potential for sunken costs that might never result in revenue.

The main channels for “inter-technological” communication are the public PL providers like KICET. They help SME with advice and support. Furthermore, there exist several training programs that supply the PL-users with expertise in several areas (more information can be found in the PL policies section).

Big companies are usually not using public PL in order to stay independent. Confidentiality issues are also a big concern. Still, SME depend on public PL since they cannot afford their own PL. Another reason is the exchange of expertise.
As mentioned before confidentiality problems with certain products seems to be the most important argument against using external PL. Designing, installing and operating a PL creates a lot of know-how and confidential knowledge, especially when bearing the added R&D activities in mind. Therefore it is not a surprise that companies are keen on keeping their developments as much as a secret as possible.
The materials business is probably the most cautious when it comes to internal knowledge. It is comparably easy to recreate the newly developed technologies, therefore any mistake, such as loosing samples when using the public PL, can lead to serious problems. Additionally it needs to be said that since the materials are flowing into series pipes during the manufacturing process a complete production line would be necessary. If a public PL provides the complete facility for a single product the confidentiality is firmly kept through an exclusive lease of the line. Private PL usually shorten communication paths a lot, this is mainly due to the involvement with the respective company. Additions to the PL might easily be discussed with the top management. In most cases the company might reuse the PL for future products. In comparison to a public PL private PL might also be prepared faster since the technology being used is already known. Another reason for using private PL lies in the characteristics of the product. This is especially true for products that involve many chemical processes or a complex continuous process. Public PL might not be able to provide the required facilities.
Some PL are not used to realize the best possible quality but for the production of samples and small batches for marketing and research purposes. In these cases quality only needs to suffice, not to excel.
Sometimes the companies (not just SME) use external PL to test their already developed technologies in a real life prototype. Companies without their own PL would have to stop their production line in order to test said prototypes, this is usually not possible due to obvious reasons. Using public PL enables companies to produce these prototypes in a safe environment. In case of technical problems the institute (e.g. KICET) is able to support the companies. Some Ceramic Test Beds can also be used as a production line. Companies, especially SME, might also use these facilities as full production lines.
Public PL try to solve their confidentiality issues by using a reservation system. Companies can reserve the PL for a certain time frame. During this time only one company at a time might exclusively use the facilities. The reservation system tries to assure that know-how will not be available for other companies. The reservation system is far from being flawless: a big problem is limited capacity. Reservations for 2013 are nearly full. Also it

might be disadvantageous to use an open Test Bed. There is always the risk of material pollution due to previous production processes (e.g. pollution of Al2O3 with Fe). Some Test Beds are being kept up-to-date while others lack machinery and equipment. The latter is mainly caused by cuts in public spending. Furthermore the production size of the PL might not be suitable for the production of large sheets. This would mean that the company has to use the Ceramic Test Bed which located at another facility far away. Public PL operate between 9am to 6pm, the user has to reserve a specific time frame. Using the machinery for a longer time period is not possible, even if some problems arise during the process or if you cannot fulfil commissions. Materials are often disposed due to the short period of use. KICET cannot support companies with this is issue mainly because of the limited operation hour and complicated administrative procedures.
The machinery and facilities are not running 24/7. Therefore the machinery need preheating, this reduces the Rate of Operation and Efficiency (ROE).
Certain conditions arise if a company uses a public PL:
As an example; the 'Ceramic Test Bed' provides a webpage (http://www.ceramicstb.com/) and an ID to reserve a public Test Beds for ceramic materials. Every company can get an ID and is able to reserve the PL for a certain time period. The timetable shows when the PL is in use, company and product names are restricted though.

2.2. Evaluation of KET polcies/KET innovation eco-System

Involving external parties other than their suppliers is usually not what Chaebols do. Regarding technological innovations the suppliers support the implantation of PL in private companies. The Ceramic Test Bed started a government project called "Material Solution Centre", which provides help during the set-up phase. The KICET as the project leader might provide match funding, but can also apply for government funding itself. These are the main reasons behind KICET's success. They have many applicants for their PL and are planning to expand their capacities in the future.

There are some government-run programs that support companies that want to establish their own PL. But since governmental involvement usually means more regulations, many administrative hurdles must be taken. Governmental regulations are too strict most of the time not allowing the companies to freely build their own PL. The government also demands innovations in certain fields.
Especially big companies want to be independent from the government, they decide to build and finance their own PL without external support.
On the other hand, the installation of a government-funded PL can aid a company. These governmental projects typically worked on R&D before. Member organizations such as equipment suppliers have years of experience on necessary equipment and machinery. This leads to increased reproducibility, production yield and decrease of material waste.

Installing a PL does not guarantee a successful product-launch in the actual market. There are cases where products that were being tested in PL did not go on to succeed in the market and became useless in the end, this resulted in depreciations. This is a problem, especially for SME. On the other hand, small amounts of products out of certain PL might convince customers and win orders, which is a precondition for the installation of mass production lines.
Companies also avoid installing PL when the management do not find the candidate products to be of real business value, when the research results are not reaching the target specifications and when there is a lack of financial resources.
In Korea it is common that big companies bargain hard with the facility/equipment suppliers to lower the price as much as possible. As a result, suppliers are not able to employ highly skilled workers, this eventually leads to bigger companies installing in-house PL. In comparison to Korea, Germany seems to have a more rational sales-and-purchase market mechanism, leading to advanced technical competence on the supplier side. Furthermore, big companies pay up front for the pilot equipment. The purchase contract is oftentimes combined with an exclusive delivery contract with Samsung that usually runs for 2 years.

3. Conclusions

South Korea has one of the highest percentages of public spending on R&D and also has strong investments from the private side. But despite Korea's high R&D investment (high number of researches and labs), the linkage between business, universities and government is weak and needs further development. Korea does also not possess the "depth of knowledge" in either basic science or innovation and still needs to build up a better foundation of technological knowledge with more creative or innovative thinking, especially in science and technological education.[xxi]

3.1. Summary of policy perspective

The state is quite successful in supporting SME when it comes to R&D. The government influences the research areas and R&D trends in SME, while conglomerates still set the trend.

3.2. Summary of business perspective

Until now all the big companies (like Samsung, Hyundai, etc.) desire to be independent of the government. It is not only confidential issues, but also being careful when it comes to the state and ministries influencing private companies. SME receive excellent and necessary support from the government. This government-run support system is mainly addressing R&D and S&T programs. It indirectly aids the development and distribution of PL. Main barriers might be international cooperation, in which the government and business institutions have to work on the provision of information.

3.3. Recommendations to support pilot lines

Even though companies receive monetary funding by the government; there is still a need for a strong government that aids in the creation of new markets and the development of technological innovations. While the government's support regarding R&D might be sufficient, certain technologies e.g. new forms of digital displays might need a lot of support when it comes to market creation. Concluding one can say that improvements in the PL-system might aid SME but are only of little interest for bigger companies. Especially SME depend on public PL, even though that might lead to restrictions and risks when it comes to IP. Even though the name and the process are being kept anonymous sharing a PL is always risky. If many companies share a PL material pollution might occur (e.g. pollution of Al2O3 with Fe). Smaller PL in the province, and away from the metropolitan city Seoul, usually have budget problems and are therefore equipped with outdated machinery while new and bigger PL receive annual investments and modern equipment (machines). The production size of some PL is often not suitable for large-scale production and companies need to fall back on PL that are situated in more rural areas. Most public PL operate only between 9am and 6pm. If you want to use the machine you have to reserve a specific time frame. That is why using the machine for longer periods of time is impossible. Even if you face problems during the process or cannot fulfil commissions you will have to make space for the next company in line. Even though KICET normally provides support, they will not be of aid in said, mainly due to limited operation hours and complicated administrative procedures.

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4.2. Interviews

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5. Annex

5.1. Examples of pilot productions in Korea

Korea Institute of Materials Science (KIMS)	Government funded research institute providing among others test and evaluation. KIMS is acting as a hub for material convergences and processing technology, metallurgy and processing technology, authorization and certification of components, ceramics, processing technology, surface related materials and processing technology. They operate public pilot production lines.
Korea Research Institute of Chemical Technology (KRICT)	KRICT seeks to improve the competitiveness of the chemical industry and to promote the establishment of new national scale industries by developing and disseminating original chemical technologies and relevant convergence technologies. Furthermore they managine the public chemical technology infrastructure. They operate public pilot production lines.
Korea Institute of Ceramic Engineering and Technology (KICET)	Government-sponsored entity for Korea's ceramic industry providing it with R&D assistance related to research and development in the field of ceramic technology, testing, analysis/evaluation of ceramic raw materials and products and technology support for businesses in ceramic-related industry. They operate public pilot production lines.
Private pilot productions identified in the study were requested to be not disclosed.	

5.2. Pilot production status in Korea

Field	Product	Organization		Remark
		Name	Size / Type	
Secondary Battery	Nano silicon slurry	OCI	Large company	
	Li-ion battery separator	SK Innovation	Large company	
	Li-ion battery	LG Chem., Samsung SDI	Large company	
	Chemical flow battery	Lotte Chemical	Large company	
Display	Flexible display	Samsung Display, LG Display	Large company	
	Oled	Samsung Display, LG Display	Large company	
	Led	Samsung Electronics	Large company	
Nano materials	CNT	Jeio	Sme	
	Carbon fiber	KCTECH (Korea Institute of Carbon Convergence Technology)	Public research institution	
Electronics materials & components	PPS (poly phenylene sulfide)	Initz (Joint venture between SK Chemical & Japan's Teijin)	Large company	
	FCCL (flexible copper clad laminate)	-	Large company	non-disclosable
	Semiconductor	ETRI (Electronics and Telecommunications Research Institute)	Public research institution (open for public use)	
	Metal	KIMS (Korea Institute of Materials Science)	Public research institution (open for public use)	
	Semiconductor and electronics devices	KICET (Korea Institute of Ceramic Engineering and Technology)	Public research institution (open for public use)	
Printed Electronics	Nano particles using electron beam for series production	KAERI (Korea Atomic Energy Research Institute)	Public research institution (not publically opened)	

Field	Product	Organization		Remark
		Name	Size / Type	
Biofuels	Bioethanol from red macroalgae (seaweed)	BIOLSYSTEMS (a spin-off company from KITECH)	Public	
	Biobutanol	GS Caltex	Large company	
PV	Thin film pv	Samsung SDI	Large company	
	DSSC	Dongjin Semichem	SME	
	PV performance tests	Smart Process Technology Center of KITECH (Korea Institute of Industrial Technology)	Public research institution	
Automobile	Auto parts	-	Large company	non-disclosable
	Car body module using hot stamping process	MS Autotech	SME	
Super fiber	Meta-aramid	Huvis	SME	
Green plastics	Polymer made of CO2	SK Innovation	Large company	

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