# Comparison of European and non-European regional clusters in KETs

## The case of semiconductors

**FINAL REPORT**

A study prepared for the European Commission
DG Communications Networks, Content & Technology

*Digital Agenda for Europe*

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# Table of contents

# List of abbreviations

| Abbreviation | Description |
|---|---|
| **A** | |
| **AENEAS** | Association for European NanoElectronics Activities |
| **AMD** | Advanced Micro Devices |
| **AMTC** | Advanced Mask Technology Center |
| **ASML** | ASML Holding N.V. |
| **ASIC** | Application-Specific Integrated Circuit |
| **B** | |
| **B2B** | Business-to-Business |
| **C** | |
| **CATRENE** | Cluster for Application and Technology Research in Europe on Nanoelectronics |
| **CEA** | Consumer Electronics Association |
| **CENN** | Center of Excellence in Nanoelectronics and Nanotechnology |
| **CNRS** | Centre National de la Recherche Scientifique (National Center for Scientific Research) |
| **CRSSA** | Centre de Recherches du Service de Santé des Armées (Research Center of the Army Health Services) |
| **CSP** | Case Study Protocol |
| **CSIA** | China Semiconductor industry Association |
| **CIR** | Crédit Impôt Recherche (Research tax credit) |
| **CCIG** | Grenoble Chamber of Commerce and Industry |
| **CNT** | Center Nanoelectronic Technologies |
| **CNSE** | College of Nanoscale Science and Engineering |
| **CITRIS** | Center for Information Technology Research in the Interest of Society |
| **CIMTT** | Zentrum für Produktionstechnik und Organisation (with respect to Computer Integrated Manufacturing) |
| **CSEM** | Centre Suisse d'Electronique et de Microtechnique (Swiss Center for Electronics and Microtechnology) |
| **CIP** | Competitiveness and Innovation Framework Programme |
| **CP** | Collaborative Projects |
| **D** | |
| **DG CONNECT** | Directorate General for Communications Networks, Content and Technology |
| **DSP** | Digital Signal Processing |
| **DRAM** | Dynamic Random Access Memory |
| **E** | |

| Abbreviation | Description |
|---|---|
| **EDA** | Electronic Design Automation |
| **EMBL** | European Molecular Biology Laboratory |
| **ESRF** | European Synchrotron Radiation Facility |
| **EU** | European Union |
| **EUR** | Euro |
| **EC** | European Commission |
| **ESIA** | European Semiconductor Industry Association |
| **EURAB** | European Research Advisory Board |
| **EIF** | European Investment Fund |
| **EIB** | European Investment Bank |
| **EB** | Employment-Based |
| **ERSO** | Electronics Research & Service Organization |
| **ELAt** | Eindhoven-Leuven-Aachen triangle |
| **EPSRC** | Engineering and Physical Sciences Research Council |
| **F** | |
| **FTA** | Free Trade Agreement |
| **FYP** | Five-Year-Plan |
| **FTG** | Foreign Trade Group |
| **FPGA** | Field-Programmable Gate Array |
| **FP7** | EU's Seventh Framework Programme for Research |
| **FIRDI** | Food Industrial Research and Development Institute |
| **FP** | Framework Program |
| **FTE** | Full-Time Employees |
| **G** | |
| **GDP** | Gross Domestic Product |
| **GSA** | Global Semiconductor Alliance |
| **G450C** | Global 450mm Consortium |
| **GAMS** | Governments/Authorities Meeting on Semiconductors |
| **GREX** | World Trade Centre of the Grenoble Chamber of Commerce and Industry |
| **GBP** | British Pound |
| **H** | |
| **HSP** | Hsinchu Science Park |
| **HVCC** | Hudson Valley Community College |
| **I** | |
| **IC** | Integrated Circuit |

| Abbreviation | Description |
|---|---|
| **ICT** | Information & Communication Technologies |
| **IDM** | Integrated Device Manufacturer |
| **ILL** | Institut Laue-Langevin |
| **INRA** | Institut National de la Recherche Agronomique |
| **Inserm** | Institut national de la santé et de la recherche médicale |
| **IP** | Intellectual Property |
| **IPO** | Initial Public Offering |
| **ISA** | India Semiconductor Association |
| **IST** | Information Society Technologies |
| **ID** | Interactive Dialogues |
| **IT** | Information Technology |
| **IWT** | Agentschap voor Innovatie door Wetenschap en Technologie (Agency for Innovation by Science and Technology) |
| **ITA** | Information Technology Agreement |
| **ISMTN** | International SEMATECH North |
| **ITRI** | Industrial Technology Research Institute |
| **IRR** | Internal Rate of Return |
| **J** | |
| **JEI** | Jeune Entreprises Innovantes (Young Innovative Enterprises) |
| **JU** | Joint Undertaking |
| **JEITA** | Japan Electronics and Information Technology Industries Association |
| **JTI/JU** | Joint Technology Initiative/Joint Undertaking |
| **K** | |
| **KETs** | Key Enabling Technologies |
| **KSIA** | Korea Semiconductor Industry Association |
| **KIC** | Knowledge and Innovation Community |
| **KU Leuven** | Katholieke Universiteit Leuven |
| **L** | |
| **LCMI** | Laboratoire des Champs Magnétiques Intenses (Grenoble High Magnetic Field Laboratory) |
| **M** | |
| **MINT** | Mathematics, Informatics, Natural science and Technology |
| **MCO** | Multi-component ICs |
| **N** | |
| **NACE** | Nomenclature statistique des activités économiques dans la Communauté Européenne (European industry standard classification system) |

| Abbreviation | Description |
|---|---|
| **NUTS** | Nomenclature d'unités territoriales statistiques (Geographical coding standard) |
| **NDF** | National Development Fund |
| **NTB** | Non-Trade Barriers |
| **NaMLab** | Nano-electronic Materials Laboratory |
| **NASA** | National Aeronautics and Space Administration |
| **NCTU** | National Chaio Tung University |
| **NTHU** | National Tsing Hua University |
| **NMI** | Trade association representing the U.K. Electronic Systems, Microelectronics and Semiconductor Communities |
| **NEMS** | Nanoelectromechanical Systems |
| **O** | |
| **OECD** | Organisation for Economic Co-operation and Development |
| **OEM** | Original Equipment Manufacturers |
| **P** | |
| **PC** | Personal Computer |
| **PPP** | Public-Private Partnerships |
| **R** | |
| **R&D** | Research and Development |
| **R&D&I** | Research, Development & Innovation |
| **RF** | Radio Frequency |
| **RTCs** | R&D Tax Credits |
| **RoO** | Rules of Origin |
| **R/R&D** | Federal Research/Research and Development |
| **S** | |
| **SBIR** | Small Business Innovation Research |
| **SME** | Small-Medium Enterprise |
| **SEC** | U.S. Securities and Exchange Commission |
| **SEMI** | Semiconductor Equipment and Materials International |
| **SOE** | State-Owned Enterprise |
| **SoC** | System-on-a-Chip |
| **SSW** | Silicon South West |
| **SOI** | Silicon-on-Insulator |
| **Sematech** | Semiconductor MAnufacturing TECHnology |
| **STEM** | Science, Technology, Engineering and Mathematics |
| **SME** | Small to Medium-sized Enterprise(s) |

| Abbreviation | Description |
|---|---|
| **SMT** | Semiconductor Manufacturing Technology |
| **SIA** | Semiconductor Industry Association in the United States |
| **SIG** | Special Interest Groups |
| **SSE** | Stanford Student Enterprises |
| **S&T** | Science and Technology |
| **SPA** | Science Park Administration (of the Hsinchu Science Park) |
| **SBRI** | Small Business Research Initiative |
| **T** | |
| **TGV** | Train à Grande Vitesse (High speed train) |
| **TSIA** | Taiwan Semiconductor Industry Association |
| **TSMC** | Taiwan Semiconductor Manufacturing Company |
| **TBT** | Technical Barriers to Trade |
| **TPM** | Trusted Platform Module |
| **TU/e** | University of Eindhoven |
| **TEL** | Tokyo Electron Limited |
| **TTO** | Technology Transfer Office |
| **TRL** | Technology Readiness Level |
| **U** | |
| **UK** | United Kingdom |
| **US** | United States |
| **USD** | U.S. Dollar |
| **UMC** | United Microelectronics Corporation |
| **UAlbany** | University at Albany |
| **UC** | University of California |
| **V** | |
| **VC** | Venture Capital |
| **VIS** | Vlaamse Innovatiesamenwerkingsverbanden (Flemish Cooperative Innovation Networks) |
| **VLSI** | Very-Large-Scale Integration |
| **W** | |
| **WP** | Workplace |
| **WTO** | World Trade Organisation |
| **WSC** | World Semiconductor Council |
| **Z** | |
| **ZGC** | Zhongguancun |
| **ZμP** | Center of Microtechnical Manufacturing |

# *Index of Tables*

# *Index of Figures*

# Abstract

The current study aimed to analyse the main activities and measures required to create, expand and keep nanoelectronics clusters in Europe competitive. The conclusions of the study are based on the analysis of four European and four non-European clusters.

The analysis has shown that particularly Asian clusters benefit from a wide range of incentives offered by the government. However, while Asia is home to some of the leading semiconductor manufacturing sites, the clusters there are reported to be less competitive in design. Leading-edge research still tends to be located in Europe and the US. Clusters in Europe and the US tend to represent concentrations of organisations with or without a central initiative, while in Asia, clusters are mainly represented by scientific parks.

The Final Report of the study provides a detailed overview of findings for Europe, Asia and the US within the seven dimensions of public policies and incentives. The study has also produced a set of evidence-based policy recommendations on linking national/regional-level clusters and the most effective measures to (future) European-level programmes. The recommendations cover the areas of technology transfer from research organisations to companies, R&D&I skills, tax incentives, innovation and industrial policy regimes, and State Aid.

# *Executive summary*

The current report represents the Final Report for the study on the "Comparison of European and non-European regional clusters in KETs: The case of semiconductors" carried out by PricewaterhouseCoopers EU Services EESV (hereafter PwC) for Directorate General for Communications Networks, Content and Technology (hereafter "DG CONNECT") of the European Commission. The study aimed to analyse the main activities and measures required to create, expand and keep nanoelectronics clusters in Europe competitive based on the analysis of four European and four non-European clusters. The report presents the key findings of the study and offers evidence-based policy recommendations on linking national/regional level clusters and the most effective measures to future European-level programmes.

Semiconductors enable many of the key technologies and innovations required for advancing a sustainable information and communication economy. The semiconductor industry is thus crucial for Europe's competitiveness. In turn, an important condition for achieving global competitiveness is the grouping of semiconductor suppliers and end-users into clusters. Such clusters or nanoelectronics eco-zones offer local employment, ensure local sourcing in Europe for systems suppliers and trigger the establishment of local branches of non-European high-tech industries. Finally, clusters contribute significantly to European high-tech exports. Consequently, to build a European leadership position in a targeted way, effective measures are required to support the development of the semiconductor clusters in Europe.

To identify such measures, a detailed analysis was conducted of policy and other measures present in a sample of global semiconductor hotspots. These included *four European clusters*: Grenoble cluster (Grenoble, France); Silicon Saxony (Dresden, Germany); DSP Valley and Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium); and Silicon South West (South West England, UK); and *four non-European clusters*: Silicon Valley (San Francisco Bay Area, US); Tech Valley (Albany, US); Zhongguancun (Beijing, China); and Hsinchu Science and Industrial Park (Hsinchu, Taiwan). The sample of clusters thus allowed for comparisons of relevant measures between Europe, US and East Asia. Three consequent stages of the study include (1) cluster-level case study analysis; (2) cross-case analysis and identification of common patterns within regions; and (3) synthesis and extraction of policy recommendations.

The Asian clusters appear to receive most public support. A wide range of incentives are in place and companies can apply for a number of benefits. While Asia is home to some of the leading semiconductor manufacturing sites, the clusters there are less competitive in design. Despite strong governmental funding and high R&D tax incentives, leading-edge research still tends to be located in Europe and the US. Clusters in Europe and the US tend to represent concentrations of organisations with or without a central initiative, while in Asian countries, especially in the development markets, clusters are mainly represented by scientific parks.

As long as the US remains the largest and most sophisticated market for technology products, new product design and leading-edge innovation are expected to remain there. At the same time, Asian companies continue to enhance their ability to design, modify and adapt, as well as rapidly commercialise technologies developed elsewhere. That makes these companies increasingly well-positioned to take new product ideas and technologies and quickly integrate and produce them in high volume at low cost. In this highly competitive global environment, Europe urgently needs a set of intelligent measures which would allow its clusters to sustain and improve their global competitiveness, otherwise the momentum will be lost.

### *Key findings*

**(1) Policy measures and incentives**

*State Aid*

- The analysed European clusters report to have benefited from State Aid in one form or another. The provided aid is mainly related to R&D support which corresponds to the general trend in Europe.
- Although in the US, the State Aid process appears to be less regulated and controlled, it is still reported to be highly bureaucratic, political and public, with lots of media attention surrounding the negotiations.
- State Aid detected in Asian clusters refers to R&D related support, and includes mainly grants to firms, loans and guarantees below market rates, and tax exemptions.

*Tax incentives*

- Most tax incentives in the European clusters are explicitly linked to R&D activities. With the exception of Germany, R&D tax credits comprise a key instrument.
- Tax regime in the US is associated with ongoing fiscal challenges and growing tax burdens. The country has one of the world's highest corporate tax rates.
- The Asian clusters showcase a number of aggressive tax incentives, including the use of R&D tax credits, tax holidays and tax deferrals.

*Favourable trade conditions*

- Trade in this sector for the EU is dominated by imports, particularly from the US, Japan, China and other East and South-East Asian countries. While tariffs are mostly covered, non-tariff barriers are a key issue for the EU industry.
- Semiconductors form a large part of the US export. Excessive restrictions, however, often suppress the ability of US companies to compete with foreign competitors that do not have the same export-related administrative and bureaucratic burdens.
- By joining the WTO, the analysed Asian countries became part of the Information Technology Agreement (like EU and US) which eliminates tariffs on most semiconductor products.

*Pre-commercial public procurement*

- European pre-commercial public procurement is currently underutilised. Although several initiatives are already in place, it is too early to talk about their success.

- The US public sector spends billions of USD per year on the procurement of R&D. This has often played an important role in improving the quality of public services and in the emergence of globally competitive companies.

- While procurement is an important aspect of the innovation strategy in China, the role of procurement for the semiconductor industry in Taiwan is reported to be highly limited.

*Access to finance*

- There is insufficient level of venture capital available in the European clusters. This leads to deprivation of the innovative activities and slower growth of SMEs, and the whole financing burden is often placed on the public funding.

- Venture financing of US semiconductor companies has considerably dropped in the last few years. Nowadays, most US companies do not consider manufacturing their own products and choose to outsource it to, for example, Taiwanese businesses instead.

- The current state of the Chinese VC industry is far from completely developed, but the recent trends suggest growth at a tremendous pace.

- The Taiwanese venture capital industry is the third most active venture capital market in the world, and has been a stable source of funding for SMEs.

*Public-private partnerships*

- Public-private partnerships are often reported to be at the centre of the clusters' development in Europe.

- Large semiconductor and electronics companies currently headline a group of Silicon Valley elite partnering with the Obama administration to create entrepreneurial clusters and aid start-up companies around the country.

- While public-private partnerships are relatively new in China, it is suggested that there is great potential for their application due to the strong demand for public facilities and services.

- The level of collaboration between industry and universities in Taiwan is relatively high, with Taiwan ranking seventh in the world in this dimension.

*Other means*

- Europe has to deal with a trend of a brain drain of technical talent due to the combined influence of an ageing population and the fact that less children are choosing to pursue technical education and careers.

- The current US immigration policies prevent American companies from retaining or recruiting the world's best innovators – including many who have been educated at US universities.

- Asian clusters are reported to benefit from a 'reverse' brain drain, which implies that thousands of local engineers who have previously studied and/or worked abroad have subsequently returned to China or Taiwan to either start companies themselves or work for start-ups or already established companies.

- Low salaries often result in inability of Asian clusters to retain local talent and attract foreign highly skilled workers.

**(2) R&D&I capacities**

- One of the major strengths of the European clusters is the presence and high density of research institutions.
- The analysed US clusters host world-class R&D centers as well as top universities in the field.
- While the Asian clusters also have access to top universities and research centres, their share in semiconductor R&D and design is still comparatively low.

**(3) Effect of innovation policy and industrial policy regimes**

- European clusters emphasise the need to bridge the gap between design and manufacturing.
- The US clusters sometimes suffer from the local regulations and taxation policies that hinder the growth of innovative industries.
- For Asian clusters, favourable tax conditions, generous public support, high quality of engineers, and top universities in the proximity were identified as factors that support semiconductor manufacturing.

**(4) Technology transfer from research organisations and universities to companies**

- The "European model" of technology transfer represents a top-down approach. Governments tend to stimulate specific forms and strategies of technology transfer.
- The "US model" of technology transfer follows a bottom-up approach. Policy focus is on creating requirements and incentives for public research organisations which, in turn, stimulate them to intensify their commercialisation efforts.
- Both China and Taiwan are reported to have adapted their laws to create an IP system that responds to global demands and meets international standards.

**(5) Technology transfer between the nanoelectronics manufacturing companies and different application customers**

- EU-wide programmes such as ARTEMIS and ENIAC provide semiconductor companies with easier access to end-user industries across Europe, but improvements can be made in terms of easing administrative requirements.
- For US clusters, incorporation of end-user industries faces cost-related challenges leading to the situation that increasingly more companies are deciding to move their facilities to other countries.

- Due to lower average salaries and other costs, Asian clusters are reported to be attractive locations for companies from other regions. At the same time, no evidence was found that the incorporation of end-user industries is part of a governmental policy for the local industry.

**(6) Clustering models**

- European clusters are typically organised as a network system. European cluster organisations are typically characterised as medium in size, have a multi-sectoral orientation and are funded by a mix of public and private funds.

- In the US, clusters also take a form of a network system. The clusters are, however, not centrally coordinated by a single cluster organisation.

- In Asian countries, clusters are mainly represented by scientific parks. The cluster organisations play a central role. The management board often includes people that hold government positions.

**(7) Potential for new clusters or further networking**

- Several emerging hotspots were identified, which include New York, Washington D.C., Boston, Austin, Bangalore.

- Areas like Bangalore (India) or Beijing (China), which possess highly educated labour force with much lower salaries, pose significant threats to existing semiconductor clusters, especially in older technologies further along in their lifecycle.

***Recommendations***

**(1) Measures to stimulate technology transfer from research organisations to companies**

- There is a need to develop an integrated *European-level* SBIR programme with strong coordination mechanisms and competitive budgets.

- Some specific requirements for the European-level SBIR programme include consistent multi-year programmatic approach split into several phases; covering also higher technology readiness levels; applying no dilution of ownership or repayment required; offering competitive budgets with 100% funding; applying strong coordination mechanisms to minimise the risk of lack of coordination from the policy makers' side; and including entrepreneurs, industry experts, investors, as well as scientists in the evaluation panels.

- Europe's institutions need to implement uniformity in terms of legal aspects for technology transfer.

**(2) Measures to stimulate R&D&I skills**

- Europe needs a set of urgent and effective policy measures to tackle the shortage of skilled labor for the semiconductor industry. Rather than having a few fragmented ad-hoc initiatives, there is a clear need for an integrated and systematic European-level approach. Some key features of such measures should include the following:

- Aiming to increase the prestige of working in the semiconductor industry;
- Developing highly specialised educational programmes;
- Targeting different age groups starting from the early age; teachers with the appropriate tools to facilitate the learning process.
- Close cooperation of policy makers and educators with industry in developing and implementing educational programmes;
- Incorporating the multi-disciplinary nature of KETs into the school curriculum.

**(3) Tax incentives**

- R&D tax incentives need to be introduced in European regions that currently do not have such incentives in place.
- Existing R&D tax incentives need to be expanded to level the effective corporate tax rates for R&D related activities with the "best-in-class" region.
- Innovation-friendly tax incentives should be further explored as an alternative to aggressive tax holidays found particularly in the East Asian countries.

**(4) Innovation and industrial policy regimes**

- Large companies play a central role in the development of the European and global semiconductor industry. Europe needs specific measures helping to keep large semiconductor companies in the region (e.g., favorable tax incentives, softer State Aid rules).
- Policy makers should support financing of and cooperation between companies that intend to invest into latest production technologies and manufacturing sites located in Europe.

**(5) State Aid**

- State Aid should be considered in the context of European semiconductor clusters in areas where Europe has a competitive gap with the rest of the world (for example, in terms of indirect costs, skilled personnel and physical infrastructure).
- A critical viewpoint on State Aid funding is recognising that the greatest competition comes from outside Europe and not from within.
- Europe needs to re-evaluate the State Aid regulation, particularly in relation to the Regional Aid framework, in order to be able to attract and retain leading-edge manufacturing facilities in the semiconductor industry. The State Aid ceilings, which significantly dilute the Regional State Aid intensity, require special attention.
- The speed of State Aid procedures in Europe needs to be increased by streamlining the process. The aim should be to reduce the decision time to 2-3 months, which may be achieved through preventing unnecessary information requests and through involvement of all actors from the start of the procedure.

# 1. Context and objectives of the study

This chapter aims to provide the reader with the background information on the context, objectives and scope of the study, including definitions. In the end of this chapter, we also present the structure of the report.

## 1.1. Context of the study

Key Enabling Technologies (hereafter "KETs") are considered to be essential for enhancing European global competitiveness, and help solve grand societal challenges in the fields such as energy, climate change, healthcare, security, etc. These technologies are associated with high research and development (R&D) intensity, rapid innovation cycles, high capital expenditure and highly skilled employment. They are multidisciplinary, cutting across multiple technology areas with a trend towards convergence and integration. KETs have high economic potential and are considered to be the driving force of the new goods and services that will determine the market in the next ten to twenty years. Facilitating the development of such technologies is therefore essential in order to strengthen the industrial and innovation capacity of Europe, lay stable foundations for creating well-paid jobs, and allow for sustainable, broadly shared growth through managing the shift to a sustainable knowledge-based economy[1].

One of the KETs refers to nano- and microelectronics or semiconductors. The semiconductor industry provides the knowledge and technologies for other industries which, in turn, generate approximately 10% of both European and worldwide GDP[2]. Over the last decade, the semiconductor industry and its natural downstream ICT industries created more than 700,000 additional jobs in Europe, showing a trend towards rapid recovery after the crisis[3]. A strong semiconductor industry is essential if Europe is to remain one of the world's leading knowledge-based economies and realise the European Union's ambition of putting the Information Society at the heart of its strategy for the twenty-first century.

However, whether Europe's competitive advantage can be maintained or even expanded in the long term heavily depends on the support this industry receives from European policy makers. Factors such as skills, R&D, venture capital, maintaining a manufacturing base and appropriate regulation are suggested to be crucial for the future development of KETs in general and semiconductor industry in particular in Europe[4]. The appropriate measures, in turn, need to take into account the specifics of the industry.

1 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: "Preparing for our future: Developing a common strategy for key enabling technologies in the EU", COM(2009) 512 final, Brussels, 30.09.2009.

2 ESIA 2008 Competitiveness Report

3 European Commission, The 2010 report on R&D in ICT in the European Union; and European Commission, The 2011 report on R&D in ICT in the European Union, http://is.jrc.ec.europa.eu/pages/ISG/PREDICT.html.

4 "An industrial policy for the globalisation era" – Elements of the Commission's strategy, 28 October 2010, available at http://europa.eu/rapid/press-release_MEMO-10-532_en.htm

### *1.1.1. Specifics of the semiconductor industry*[5]

The semiconductor industry is highly specific in nature. It produces cutting-edge technology in chaotic and unpredictable business environments. The key principles behind the industry can be summarised as *'smaller, faster and cheaper'*. Tinier lines mean more transistors can be packed on the same chip. The higher number of transistors on a chip, in turn, means higher speed of work. Given fierce competition and new technologies that lower the cost of production per chip, the price of a new chip can fall by 50% within a matter of months. As a result, chip makers are under constant pressure to develop technologically superior and cheaper solutions which surpass products considered state-of-the-art only a few months before. Even in times of a down market, chip makers are expected to come up with better products since demanding customers will eventually need to upgrade their computing and electronic devices.

#### *1.1.1.1. Delegated production*

Traditionally, semiconductor companies controlled the entire production process, i.e. from design to manufacturing. However, nowadays, chip makers are increasingly *delegating production to others in the industry*. Foundry companies whose business is manufacturing currently provide attractive outsourcing options. Chip companies are becoming leaner and more efficient. At the same time, large manufacturers that still have in-house production facilities typically do so for the following reasons. The processor manufacturers produce, for instance, high-performance high-frequency chips with corresponding losses. In this field, extremely intensive cooperation between design and production is required. The same is applicable to memories. Accordingly, these large manufacturers are able to afford producing in-house given the tremendous volumes involved. Some also choose to do so due to the risk of foundries exerting tremendous price pressure.

#### *1.1.1.2. Cyclical nature*

The semiconductor industry is *highly cyclical*. Semiconductor companies face constant booms and declines in product demand. The demand for semiconductor products depends on the end-market demand for personal computers, cell phones and other electronic equipment. When times are favourable, large companies are not able to produce microchips quickly enough to meet the demand. However, when times are difficult, for example, when PC sales are slow, the semiconductor industry has to face tough consequences. As a result, chip makers are constantly dealing with high risks as it can take them several months or even years after a major development project to find out whether the project ends up being a tremendous success or a huge failure. One reason for this delay is the *intertwined but fragmented structure of the industry*. Different sectors have their peaks and troughs at different times. For example, the low point for foundries often arrives much sooner than it does for chip designers. Another reason refers to the industry's long lead time. It takes years to develop a chip or to build a foundry, and even longer before the products start generating returns.

[5] Based on "The Industry Handbook: The Semiconductor Industry", available at http://www.investopedia.com/features/industryhandbook/semiconductor.asp

#### 1.1.1.3. *High capital intensity*

In the early days of the semiconductor industry, engineers with good ideas would often leave one company to start up another. However, as the industry matures, setting up a chip fabrication factory requires billions of EUR worth of *investments*. As a result of the extremely high cost of entry, only the biggest players can keep up with state-of-the-art operations. This has led to established players having a huge advantage. Despite this, a new trend is emerging: semiconductor companies are forming alliances to spread out the costs of manufacturing. In the meantime, the appearance and success of so-called fabless chip makers suggests that factory ownership may not always be a barrier to enter the market.

#### 1.1.1.4. *Dominance of large players*

Large semiconductor companies have hundreds of suppliers. At the same time, with production getting more expensive, many small chip makers are becoming increasingly dependent on a few large foundries. This leads to these large foundries having considerable industry bargaining power. Accordingly, most of the industry's key segments are dominated by a *small number of large players*.

#### 1.1.1.5. *Threat of substitutes*

The industry also faces the *threat of substitutes*, although it varies per segment. A company that spends millions and even billions of EUR on the creation of a faster and more reliable chip will strive to earn back its R&D costs. However, there is always a risk that another player comes and performs reverse engineering, and then markets a similar product for a significantly lower price. While IP protection can prevent the entrance of new substitute chips for a period of time, when the period of protection expires, competitors are able to start producing similar products at lower prices within a short period of time, effectively eroding market share.

### 1.1.2. *Semiconductor industry in Europe*[6]

In the late 1980s and early 1990s, the semiconductor industry in Europe went through a period of major recovery. During this phase, many local and national champions consolidated. While this was a painful adaptation, the European semiconductor industry emerged stronger than before, generating a robust European presence in the global semiconductor market by the end of the twentieth century.

This leadership position was built in a favourable political and economic environment that also attracted significant foreign investments, and depended on continuous R&D efforts. In fact, R&D expenditure within the semiconductor industry continues to be among the highest among all industries. Such R&D-intensive efforts are necessary for engineering, designing and manufacturing products for leading electronic equipment manufacturers in application areas such as wireless communications, automotive, identification, power management and industrial equipment. Today, these application areas continue to be areas of European strength.

[6] Based on ESIA 2008 Competitiveness Report "Mastering Innovation, Shaping the Future"

However, the semiconductor industry continues to change. Following the boom and decline cycle during the years 2000 and 2001, the map of the global semiconductor landscape has been redrawn: the roles of the various economic regions of the world have been redistributed as new players have emerged and competitive pressures continue to increase. At the same time, the complexity of semiconductor products has been increasing dramatically, along with the level of investments required to sustain an up-to-date manufacturing base.

Europe's advantage is that the semiconductor industry in the region intensively works together with the users, for instance, in the automotive and engineering sectors. Interdisciplinary knowledge is necessary, and the overall environment in Europe is favourable for this purpose. Europe also has good opportunities in the growth areas of energy and environmental technology, for example, power electronics. However, commodity chips are likely to be manufactured in Asia in the foreseeable future.

### *1.1.3. Relevant EU initiatives*

The European Commission has already launched several initiatives to support the development of the semiconductor industry, some of which are listed below. For example, it has established a *High-Level Expert Group* to develop a long-term strategy for KETs. This expert group comprises of Member States' industrial and academic experts[7] and closely collaborates with the Commission's expert groups on innovation and technology, the European Institute for Innovation, the European Technology Platforms and Joint Technology Initiatives. The High-Level Expert Group's mission is to evaluate the competitive situation of KETs in Europe and their potential contribution to tackle societal changes; to evaluate the availability of public and private R&D capacities for KETs in the EU; and to propose specific policy recommendations for a more efficient and successful industrial deployment of KETs in the EU[8].

KETs are part of three flagship initiatives in the *Europe 2020 Strategy*: (1) the Digital Agenda; (2) Innovation Union; and (3) the industrial policy for globalisation. The *Digital Agenda* initiative has the ambition of outlining policies and actions that should be implemented in order to position Europe at the top in relation to the ICT industry. "ICT Research and innovation" is the fifth pillar of the EU Digital Agenda. Investment in R&D is considered to be key in attracting companies and the best competences as well as in transforming the best research ideas into marketable products and services[9].

A key objective of the Innovation Union, in turn, is to establish the right framework conditions in the EU to turn promising ideas into products and services that are successful on the market. In other words, the Innovation Union aims to boost the whole innovation chain, from research to retail, by combining world-class science and research with an innovation economy, removing bottlenecks that hamper a single market in innovation and prevent Europe from competing as it should with the rest of the world, and bringing together the main actors in key areas with the aim of striking the right

[7] The High-Level Group was formally launched in July 2010 with 27 members from EU Member States (including France, Germany and UK), industry, trade unions, research community and the European Investment Bank.

[8] Communication from the Commission to the European Parliament, The Council the European Economic and Social Committee and The Committee and The Committee of The Regions: "Preparing for our future: Developing a common strategy for key enabling technologies in the EU" – SEC (2009) 1257.

[9] http://ec.europa.eu/information_society/newsroom/cf/pillar.cfm?pillar_id=47

balance between collaboration and competition. It requires enhancing access to finance for innovative companies, creating a single innovation market, promoting openness, and capitalising on Europe's creative potential. It also requires finding ways of bridging the gap that exists between the outputs of R&D projects and innovation/commercial production[10].

The European Commission's flagship initiative on an industrial policy for the globalisation era highlights the need for industry to play a key role if Europe is to remain a leading economic power. Manufacturing is closely interlinked with R&D, as a well as other elements of an industry infrastructure including suppliers and supporting services.

Examples of specific semiconductor industry-related initiatives include EUREKA, CATRENE and ENIAC.

*EUREKA* is a leading platform that promotes international, market-oriented research and innovation through the support of small-medium enterprises (SMEs), large industry, universities and research institutes. EUREKA proposes different programmes to support the development of key technologies to maintain Europe as a leader in the world market[11].

*CATRENE* (Cluster for Application and Technology Research in Europe on Nanoelectronics), one of the EUREKA's programmes, is a co-operative R&D public-private partnership for large companies, SMEs, institutes and universities aimed at precompetitive innovations in semiconductor technology and applications. CATRENE is focused on creating European leadership in security, safety and energy-conscious transport, the growing healthcare market, environmental protection, high-quality media and entertainment and integrated communications for commerce and consumers. The focus of its projects – increasing productivity and reducing time to market – aims to ensure Europe remains a key supplier to a wide range of global markets[12].

The *ENIAC* Joint Undertaking (JU) is a public-private partnership that focuses on nanoelectronics and brings together Member/Associated States, the European Commission, and Association for European NanoElectronics Activities (AENEAS, an association representing European R&D actors in this field). The ENIAC Joint Undertaking aims to increase and leverage private and public investments in nanoelectronics which contribute to strengthen Europe's future growth, competitiveness and sustainability. It coordinates research activities through competitive calls for proposals to enhance the further integration and miniaturisation of devices and increase their functionalities while delivering new materials, equipment and processes, new architectures, innovative manufacturing processes, disruptive design methodologies, new packaging and 'systemising' methods[13].

### *1.1.4. The role of clusters*

The international position of Europe in the semiconductors sectors is supported by the presence of a few important regional clusters dealing with advanced nanoelectronics in Europe. They are, among others, located in Grenoble, Dresden, Dublin and Eindhoven/Leuven, and gather large semiconductor companies such as STMicroelectronics, Infineon Technologies, GLOBALFOUNDRIES, Intel and NXP Semiconductors.

[10] http://ec.europa.eu/research/innovation-union/index_en.cfm
[11] http://www.eurekanetwork.org/
[12] http://www.eurekanetwork.org/catrene/about
[13] http://www.eniac.eu/web/index.php

Clusters are often cross-sectoral networks made up of dissimilar and complementary firms specialising around a specific link or knowledge base in the value chain. Clusters thus can be seen as reduced-scale innovation systems. This implies that dynamics, system characteristics and interdependencies similar to those described for national innovation systems can be said to exist in individual clusters[14]. Cluster policies, in turn, comprise a set of policy activities that aim to stimulate and support the emergence of networks, strengthen the inter-linkages between different parts of the networks, and increase the added value of their actions.

A crucial element of clusters is inter-firm networks, where companies cooperate directly with each other. This cooperation can be formal, i.e. with an explicit contract (for example, a supplier contract or a joint venture), or informal. In case of the latter, cooperation may take form of informal knowledge transfer, as well as relations with "related" industries (i.e., industries which have no direct supplier relationships, but which may share some economies of scope, for example, similar technologies and similar markets).

Additionally, strategic alliances between large multinational companies are now common practice in international business. These alliances do not always represent clusters, but mostly project-related bilateral arrangements between companies and R&D laboratories. These changes in cooperation patterns can be explained by increasing global competition and rising R&D costs. Small and medium-sized enterprises feel the challenges of global competition to the same extent as large companies operating internationally. For example, a change in subcontractor relationships can be observed, with contractors requiring higher quality, greater flexibility and more complex products from their suppliers. SMEs are finding it increasingly difficult to face these challenges in isolation, and thus opportunities to cooperate with other firms and the creation of networks offer joint solutions[15].

The genesis of clusters and their further development are complex processes which are often dependent on a number of players including governmental agencies, public organisations, academic, educational and research institutions, different types of cooperating companies, suppliers, providers, and financial structures.

Geographical proximity provides a platform for strong cooperation and the flow of knowledge and expertise. Particularly important for the transfer of tacit knowledge is the personal (direct) interaction between research institutions, companies and policy makers. ***This makes regions possessing innovation clusters strategically advantageous when competing for mobile factors of production***.

## 1.2. *Objectives of the study*

In the previous sub-sections, we showed that the semiconductor industry is crucial for Europe's competitiveness. An important condition for achieving global competitiveness, in turn, is the grouping of semiconductor suppliers and end-users into *clusters*. Such clusters or nanoelectronics eco-zones offer local employment, ensure local sourcing in Europe for systems suppliers and trigger the establishment of local branches of non-European high-tech industries. Finally, these clusters contribute significantly to European high-tech exports. At the same time, to build a European

[14] "Boosting innovation: the cluster approach" (1999), OECD proceedings
[15] Boekholt P. (1997) "The Public Sector at Arm's Length or in Change? Towards a Typology of Cluster Policies", paper presented at the OECD Cluster Focus Group Workshop in Amsterdam, 9-10 October 1997

leadership position in a targeted way, effective measures are required to support these clusters. ***The objective of this study is therefore to identify and validate a broad set of measures that are required to create, expand and keep semiconductor clusters in Europe competitive.***

The subject of the study is ***a detailed analysis of four regional semiconductor clusters outside Europe, a comparison of the four non-European clusters with four European clusters in this field, as well as an identification of elements which define the competiveness of such clusters***.

### 1.2.1. Cluster approach

The cluster approach can be used as an important analytical tool to underpin industrial and technology policy. Below we list some specific contributions from using the cluster approach for policy analysis[16].

- Clusters can be viewed as *reduced-scale national innovation systems*. The dynamics, system characteristics and interdependencies of individual clusters are similar to those of national innovation systems. Focusing on knowledge linkages and interdependencies between actors in networks of production, the cluster approach offers a useful alternative to the traditional sectoral approach.
- Clusters can be identified at *various levels of analysis*. Micro-level analysis focuses on inter-firm linkages, while meso-level analysis looks at inter- and intra-industry linkages of the production chain. In turn, macro-level analysis examines how industry groups constitute the broader economic structure.
- Cluster analysis indicates great *diversity in innovation paths* depending on the knowledge base of the clusters concerned. This calls for differentiation in policy analysis and policy making.
- Cluster analysis can provide insights into *identifying economic strengths and weaknesses*, gaps in innovation networks, development opportunities for regions, infrastructure needs, and targets for enhanced investment in science and knowledge.
- Governments can nurture the development of innovative clusters through the provision of appropriate policy frameworks in areas such as education, finance, competition and regulation. Additionally, schemes to stimulate knowledge exchange are also valuable, including schemes addressing knowledge failures and strengthening cooperation among firms. Focused R&D schemes, innovative public procurement, investment incentives and the creation of centres of excellence are more direct policy tools. European, national and regional policies can play a role in encouraging cluster formation and development.

The outcomes of the analysis have led to the following recommendations for industrial and technology policy:

- Improving the design of regulatory frameworks (for example, through the elimination of regulatory distortions which tend to favour well-established industries to the detriment of new, and therefore smaller, innovative industries);
- Creating complementary human capital through government spending on education;

[16] "Boosting innovation: the cluster approach" (1999), OECD proceedings

- Raising public awareness of potential opportunities, especially with regard to new technologies through the dissemination of relevant information;
- Triggering demand-pull effects by means of, for example, (pre-commercial) public procurement;
- Setting priorities for focused R&D support schemes; *and*
- Using the cluster concept as an instrument for the focused marketing of semiconductor business locations in Europe, thus providing an internationally visible profile for potential investors and further strengthening clusters by attracting an inflow of foreign direct investment.

***Cluster analysis thus offers valuable insights into how the competitiveness of the European semiconductor industry can be enhanced in the global market, which is the key objective of this study***.

### 1.2.2. Outcomes

The study resulted in evidence-based policy recommendations for the European policy makers in order to:

- *Improve the "European advantage" of the semiconductor industry and value chain*. This means identifying semiconductor clusters which are of importance for Europe, and ensuring that favourable conditions are put in place to sustain or develop their competitive position.
- *Improve the attractiveness, economic performance and development of Europe*. Many development agencies, intermediaries and policy makers at Members State and regional levels have already taken up this approach. Some regions with an active cluster policy use a mix of policy instruments such as inward investment, supply chain development, SME networking and support of emerging technologies.
- *Intensify industry-research collaboration in the field of semiconductors*. There is potential for encouraging industry-research networks and centres of excellence with the aim of stimulating more user-oriented research. The objective of such approach is to build economic strength in enabling technologies. It is assumed that firms specialising in enabling technologies will develop more rapidly if they can share complementary assets with other firms. Public action should be launched with the aim of creating "critical mass" in newly emerging fields of technology by attracting research facilities, funding, large investors with R&D capabilities, and new technology-based firms.

As the key output of the study, we aim to develop policy recommendations for linking national/regional level clusters and the most effective measures to the future European level programmes such as Horizon 2020 and others. The study specifically focuses on the measures which can be adopted at the European level.

### 1.2.3. Link with other initiatives

In the course of this study, we actively engaged in a cross-exchange of concepts/ideas with the SMART 2011/0063 study ("Strategies for innovative and effective ICT Components & Systems

Manufacturing in Europe"), particularly with respect to manufacturing. The SMART 2011/0063 study aimed to provide recommendations to EU policy makers for strengthening the competitiveness of European electronics manufacturing by establishing links between the European level and the regional/national level funding and support programmes. The future orientation and structure of the European Industrial, Research-Development-Innovation and Info-Communication Policies were also considered. The study identified existing regional and national level clusters, programmes and measures and assessed their effectiveness. It also included an analysis of funding instruments and proposed possible new measures.

While this study exclusively looks at the semiconductor industry, including linkages with other electronic components and applications (*depth*), the SMART 2011/0063 study covered the full value chain (*breadth*). These approaches are of complementary nature, and their combination allows for a more comprehensive understanding of the subjects in question.

## *1.3. Definitions and scope*

In the current sub-section, we address the key definitions employed for the needs of the study, as well as its scope.

### *1.3.1. Semiconductor industry*

The semiconductor industry referred to in this study includes:

- Integrated Circuit (IC) technologies and manufacturing;
- Semiconductor manufacturing equipment and materials;
- Design of ICs (related to manufacturing);
- R&D infrastructures and public research; *and*
- Public programmes and subsidies for the nanoelectronics industry worldwide.

#### *1.3.1.1. Semiconductor manufacturers*

Semiconductor manufacturers can have various business models and can be classified as integrated device manufacturers (IDM), fabless, licensing, foundry and back-end processes (assembly and test, packaging). The business models differ in their value creation. Figure 1-1 illustrates the interaction between the various sectors.

IDMs are companies which operate along the entire value chain in semiconductor manufacturing. The considerable levels of investment for a new semiconductor facility have resulted in many IDMs switching over to what is known as a fab-light strategy. This means that existing production capacities are retained and that newly developed semiconductors, which require more modern manufacturing procedures (resulting from very small feature sizes, for example), are manufactured by partner companies.

On the other hand, fabless companies focus exclusively on R&D, as well as sales of products. They do not have their own production facilities; they use semiconductors manufactured by other companies. Not only are no costs incurred for establishing production facilities, no fixed costs are incurred in conjunction with these factories.

Some companies devote themselves exclusively to licensing (IP companies). These companies specialise in the design of certain modules and license the resulting IP to their customers. Unlike fabless companies, IP companies do not have sales operations and license their design and development services exclusively to third parties. There are also companies that focus on electronic design automation (EDA). Compared with the other business models, the volume of sales generated by IP and EDA companies forms a small part of the overall market.

Foundries do not do product development. They manufacture semiconductors in their own facilities for other market participants, such as fabless companies. Foundries mostly operate at high levels of capacity utilisation by managing commissioned production.

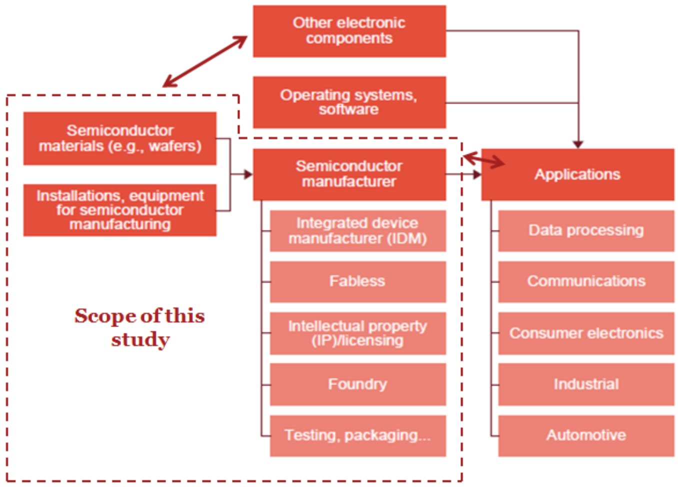


FIGURE 1-1: The semiconductor industry and its environment[17]

### *1.3.1.2. Semiconductor products*

Semiconductors are broken down into discrete semiconductor elements such as diodes, thyristors and transistors, and integrated circuits that connect numerous discrete semiconductors and thus provide a high degree of functionality.

Integrated circuits include memory, micro and logic families. Most sales are attributable to memory modules (approximately 18% of the worldwide semiconductor market), microprocessors and microcontrollers (approximately 21%) and logic semiconductors (approximately 29%)[18]. Digital integrated circuits accordingly account for virtually 70% of the worldwide market volume. The standard products consist mainly of memory products, which face fierce competition and price pressure. With application and customer-specific products, price pressure is less pronounced because of the focus on specific application aspects of specific customers.

[17] Adapted from PwC report "A change of pace for the semiconductors industry?", 2009, available at http://www.pwc.com/en_GX/gx/technology/pdf/change-of-pace-in-the-semiconductor-industry.pdf
[18] PwC analysis, figures for 2008

Effective entry barriers to competitors are customer contacts, earned through a design tender procedure, and IP rights for certain application characteristics. Product development and chip design in line with the needs of customers are extremely important to be successful in design tender procedures. They accordingly constitute factors of success.

In case of standard products, efficient mastery of the production process is a critical factor, in view of the typically high production scales. The 'yield', a parameter which provides information concerning the number of non-defective chips from each wafer processed, is a key metric. Moreover, effective capacity and its utilisation are important for the production of standard products, because the modern production facilities used, for instance, in memory production, have a high capacity and require high levels of investment to set up.

### *1.3.1.3. Semiconductor value chain*

The semiconductor value chain can be broken down into primary and support activities. Primary activities consist of silicon extraction, raw wafer production, semiconductor design, mask production, front-end and back-end production processes, logistics, marketing and sales. Support activities include infrastructure, human resources, technology, financing, management and administration, purchasing and procurement. Figure 1-2 illustrates the interrelation between these factors.

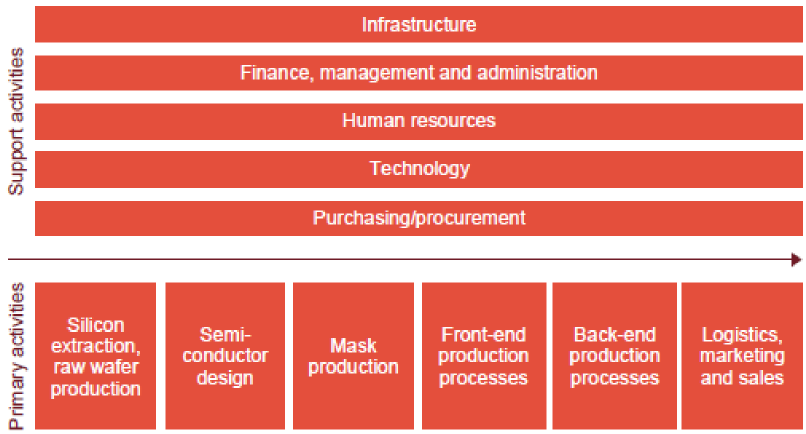


FIGURE 1-2: Semiconductor value chain[19]

In the innovation-driven semiconductor industry, the technologies in the chip production processes, the materials used and the chip design are all of vital importance. The functionality of the semiconductors and their feature sizes and production efficiency, which is also reflected in the processing of large wafer diameters, have important roles to play in this respect.

Key components in semiconductor production, in particular wafers, frequently require individual purchasing and procurement conditions and are purchased in accordance with supplier-specific specifications. For instance, to ensure the required purity level of the silicon, wafers have to be tailored specifically to meet the requirements of the individual production process of the fab.

[19] PwC report "A change of pace for the semiconductors industry?", 2009, available at http://www.pwc.com/en_GX/gx/technology/pdf/change-of-pace-in-the-semiconductor-industry.pdf

Financing and control are also important as a result of the industry's capital intensity, high pace of innovation and cyclical nature.

### *1.3.2. Clusters*

Existing research shows that there is no unambiguous definition of what a cluster is and where its boundaries lie. The cluster concept generally comprises the following dimensions:

- Clusters are seen as geographical concentrations of specialised firms, advanced skills and competences in the labour forces, and supporting institutions which increase knowledge flows and spill-overs as a result of their proximity;

- Clusters serve the functional purpose of providing a range of specialised and customised services to a specific group of firms such as the provision of advanced and specialised infrastructure, specific business support services, training, and coaching. They facilitate "co-opetition" meaning intense competition and close cooperation at the same time;

- Clusters are characterised by a certain dynamic social and organisational element called "institutional fix" that holds the different interlinked innovation actors such as universities, businesses and public authorities together and facilitates intense interaction and cooperation amongst them. Overtime, clusters tend to develop a set of institutions, personal networks and trust; *and*

- Clusters offer a natural environment for formal and informal contacts and the exchange of business information, know-how, and technical expertise leading to technological spill-overs[20] and the development of new ideas and creative designs, products, services, and business concepts that improve the innovation of businesses.

For the needs of the current study, we use the definition by the "Community Framework for State Aid for Research and Development and Innovation"[21]:

> *Clusters are "groupings of independent undertakings — innovative start-ups, small, medium and large undertakings as well as research organisations — operating in a particular sector and region and designed to stimulate innovative activity by promoting intensive interactions, sharing of facilities and exchange of knowledge and expertise and by contributing effectively to technology transfer, networking and information dissemination among the undertakings in the cluster."*

Cluster is thus a network of production of strongly interdependent firms (including specialised suppliers), knowledge producing agents (universities, research institutes, engineering companies), bridging institutions (brokers, consultants) and customers, linked to each other in a value-adding production chain.

[20] Audretsch, D.B. and Feldman M.P. (1996) American Economic Review, 86: 630-640.
[21] "*Community Framework for State Aid for Research and Development and Innovation*", published in the Official Journal of the European Union (2006/C 323/01) of 30.12.2006 and available at http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/c_323/c_32320061230en00010026.pdf

In adopting a definition of a cluster for this study we have chosen the one that would satisfy the following two criteria:

- It would address in full the functional structure of a cluster;
- It has already been proven functional in other studies on clusters.

### *1.3.3. Sample of European and non-European clusters*

As mentioned above, the current study is based on the analysis of four European and four non-European clusters. Below we provide an overview of the clusters included in the study. For a description of the methodology used for the selection process, the reader is advised to consult *Chapter 2* of this report.

The following four *European* clusters were selected:

- Grenoble cluster (Grenoble, France);
- Silicon Saxony (Dresden, Germany);
- DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium); *and*
- Silicon South West (South West England, UK).

Four *non-European* clusters include:

- Silicon Valley (San Francisco Bay Area, US);
- Tech Valley (Albany, US);
- Zhongguancun (Beijing, China); *and*
- Hsinchu Science and Industrial Park (Hsinchu, Taiwan).

Table 1-1 provides a concise overview of the key characteristics of the selected clusters. In addition to the main sample, the reference is sometimes made to the Singapore cluster as one of the world's best practices with regard to measures supporting the semiconductor industry. A short description of the cluster is also included in the table.

TABLE 1-1: Overview of the key characteristics of the selected clusters

| Criteria | Cluster information |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Cluster name** | **1: Grenoble (Grenoble)** |
| **Website** | www.minalogic.org |
| **Country** | France |
| **Region** | Europe |
| **Establishment year** | The cluster exists since 1950s, organised initiative since 2005 |
| **Category** | Organised cluster |
| **Total employment** | **24, 700 jobs in micro-nanotechnologies and electronics**: 3,000 jobs in research; 21,700 jobs in business; 1,200 higher education graduates/year |
| **Number of companies** | 204 members: 154 companies, of which 82% are categorised as SME, 15 research centres and universities, 15 local government organisations and 4 private investors |
| **Main areas of activity** | • Micro- and nano-electronic hardware technologies<br>• Embedded Systems-on-Chips |

| Criteria | Cluster information |
|---|---|
| **Noteworthy**[22] | • Exceptional concentration of public and private research centres; first research area after Paris region<br>• 4 universities, renowned higher education, especially in science<br>• 4 international research centres: EMBL, ESRF, ILL, LCMI<br>• 8 national research organisations: CEA, CENN, Cemagref, CNRS, CRSSA, Inra, Inria, Inserm<br>• Fully developed transportation network: highways, TGV, international airports<br>• Located at the heart of the Alps (22 ski resorts less than 1 hour's drive away), near Switzerland and Italy, 250 km from the French Riviera<br>• A lifestyle that combines the pleasures of the urban and cultural life of Grenoble, Lyon and Geneva with sports and outdoor recreation activities<br>• Facilities for setting up new companies |
| **Cluster name** | **2: Silicon Saxony (Dresden)** |
| **Website** | http://www.silicon-saxony.de |
| **Country** | Germany |
| **Region** | Europe |
| **Establishment year** | Firstly referred to as a cluster in 1998, started in 1961 with the creation of the Institute of Molecular Nanoelectronics |
| **Category** | Organised cluster with a central initiative |
| **Total employment** | 46,000 |
| **Number of companies** | 1,500 |
| **Main areas of activity** | • Innovative fields of organic & printed electronics<br>• Micro and nanoelectronics<br>• Energy-efficient systems<br>• Solar Energy |
| **Noteworthy** | Almost half of the 600 engineers who have been employed by AMD in Dresden studied at Dresden University; approximately 20,000 employees in microelectronics in Saxony. |
| **Cluster name** | **3: DSP Valley and Eindhoven ASML** |
| **Website** | http://www.dspvalley.com |
| **Country** | Netherlands and Belgium |
| **Region** | Europe |
| **Establishment year** | 1996 |
| **Category** | Privately organised cluster with a central initiative |
| **Total Employment** | No data |
| **Number of members** | 69; this includes both companies and universities as well as research facilities |
| **Main areas of activity** | Design of micro-electronics hardware and embedded software technology for digital signal processing systems |
| **Noteworthy** | Spread out over comparatively large geographical area and has a strong European cooperation network with other technology clusters. |
| **Cluster name** | **4: Silicon South West** |
| **Website** | http://siliconsouthwest.co.uk |
| **Country** | UK |
| **Region** | Europe |
| **Establishment year** | 1970s |
| **Category** | Privately organised cluster with a central initiative and government support |
| **Total Employment** | ~5000 (2009, only direct employment) |
| **Number of companies** | 50 |
| **Main areas of activity** | Design in the fields of RF, video, multicore processor and reconfigurable components as well as wireless, telecoms and networking system design |
| **Noteworthy** | Fabless; concentration of designers is higher than anywhere in the world except the US and approximately 50% higher than the second most non-US concentrated cluster, Cambridge. In the last decade, start-ups in the South West have attracted more than 550 million USD in investment and |

[22] http://www.minalogic.org/146-microelectronics-research-center-grenoble-france.htm

| Criteria | Cluster information |
|---|---|
| | returned more than 800 million USD to shareholders. |
| **NON-EUROPEAN CLUSTERS** | |
| **Cluster name** | **5: Silicon Valley** |
| **Website** | http://www.siliconvalley.com/ |
| **Area/State** | San Francisco Bay, California |
| **Region** | United States |
| **Establishment year** | 1940s (Semiconductor Genealogy Chart) |
| **Category** | Geographical concentration without a central organisation |
| **Total Employment** | 1.2 million – of which 17% is in Science and Engineering (all industries) |
| **Number of companies** | 177,853 establishments, including leading global players; in 2009 174,900 non-employer firms (all industries); semiconductor industry: 41 semiconductor companies, 7 equipment producers |
| **Main areas of activity** | • Silicon chip innovations<br>• Software innovations<br>• Other technological innovations |
| **Noteworthy** | The prime example for all technology clusters in the world; employment grew with 42,000 new jobs in 2011 (+3.8% compared to +1.1% nationwide); firm closures outpaced firm openings in 2010 for the first time since 2000; 13,311 new patents in 2010, which was an increase of 30% over 2009 |
| **Cluster name** | **6: Tech Valley (Albany, US)** |
| **Website** | http://www.techvalley.org |
| **Area/State** | New York State |
| **Region** | United States |
| **Establishment year** | 2002 (establishment of Tech Valley Chamber Coalition) |
| **Category** | Geographical concentration with a central organisation for promotional purposes |
| **Total Employment** | No data |
| **Number of companies** | No data; large corporations are established in the area, but no specific information was found on the number of companies |
| **Main areas of activity** | Micro and nanotechnology, both manufacturing and R&D |
| **Noteworthy** | The area provides great opportunities and is considered to be among the globally leading locations for micro- and nano-technology. Many large scale investments have been made in Albany. The department of nano-engineering and nano-science at the University at Albany offers both graduate and undergraduate degrees in nano-engineering and nano-science. They are pioneers in offering education in these fields and considered to be among the top of their field. Moreover, a consortium of leading players (the "Global 450mm Consortium) committed a multi-billion investment in the area for the coming years. |
| **Cluster name** | **7: Zhongguancun (Haidian Park)** |
| **Website** | http://www.zgc.gov.cn/english/ |
| **Area** | Beijing |
| **Country** | China |
| **Region** | Asia |
| **Establishment year** | Officially in 1988; Zhongguancun Science & Technology Zone in 1999 |
| **Category** | Concentration of organisations without central initiative, but with government support |
| **Total Employment** | 489,000 technicians |
| **Number of companies** | 12,000 |
| **Main areas of activity** | • Electronics and information technology<br>• Bio-medicine<br>• New materials<br>• Advanced manufacturing<br>• New energy<br>• Environmental protection |
| **Noteworthy** | Dubbed China's Silicon Valley; has experienced remarkable growth; generous tax breaks and other preferential treatment by the government. |

| Criteria | Cluster information |
|---|---|
| **Cluster name** | **8: Hsinchu Science Park** |
| **Website** | http://www.sipa.gov.tw/english/index.jsp |
| **Area** | Hsinchu |
| **Country** | Taiwan |
| **Region** | Asia |
| **Establishment year** | 1980 |
| **Category** | Organised with a central initiative, though not always as heavily involved |
| **Total Employment** | 130,000 |
| **Number of companies** | 430 organisations |
| **Main areas of activity** | • Semiconductors<br>• Computers<br>• Telecommunications<br>• Optoelectronics |
| **Noteworthy** | Midterm entrant compared to other science parks; number 1 ranked cluster according to Global Competitiveness Report 2008/2009; global leading cluster of semiconductor manufacturing; some of the largest semiconductor players originate from this area. |
| **Cluster name** | **9 Singapore Global Electronics Hub (not included in the main sample of the study)** |
| **Website** | http://www.ssia.org.sg (Singapore Semiconductor Industry Association - SSIA) |
| **Area** | Singapore |
| **Country** | Singapore |
| **Region** | Asia |
| **Establishment year** | 1960s (industry started in Singapore with assembly and test facilities)[23] |
| **Category** | Geographical concentration with a trade association for promotional purposes |
| **Total Employment** | 40,000 in semiconductor industry[24] (of whom 4,600 are R&D engineers)[25] |
| **Number of companies** | ~230 semiconductors companies[26] |
| **Main areas of activity** | • Semiconductors and Disk Drives (Integrated circuit design, wafer fabrication, assembly and test activities)<br>• Electronic Modules and Components<br>• Photovoltaic Devices (solar cells)<br>• Electronic Manufacturing Services and Peripherals[27] |
| **Noteworthy** | Over the last 10 years, Singapore's semiconductor industry has consistently outpaced global semiconductor industry growth; Singapore ranks second in the world in terms of wafer capacity[28]; Home to the world's top three wafer foundry companies, three of the top six assembly and test subcontractor companies, nine of the world's top ten fables semiconductor companies, world's top three hard disk drive manufacturers, world's top five electronics manufacturing services providers[29] |

Below we provide an accompanying description of the Singapore's cluster.

Singapore's manufacturing sector, which is the largest contributor to Singapore's GDP, has its core in electronics. From its modest beginnings as having the only TV assembly plant in Southeast Asia in the 1960s, Singapore's electronics industry has grown to become a vital node in the global electronics

23 http://www.edb.gov.sg/content/dam/edb/en/resources/pdfs/factsheets/Electronics%20Factsheet.pdf

24 http://www.pmo.gov.sg/content/pmosite/mediacentre/speechesninterviews/primeminister/2011/April/Speech_by_Prime_Minister_Lee_Hsien_Loong_at_Opening_of_IM_Flash_Singapore_s_Nand_Flash_Wafer_Fab.html

25 http://www.edb.gov.sg/content/dam/edb/en/resources/pdfs/factsheets/Electronics%20Factsheet.pdf

26 http://singaporecompaniesdirectory.com/categories/singapore_semiconductors.htm

27 http://www.chbe.nus.edu.sg/undergrad/briefing/Specialization%20Micro_E_Aug2011.pdf

28 http://www.pmo.gov.sg/content/pmosite/mediacentre/speechesninterviews/primeminister/2011/April/Speech_by_Prime_Minister_Lee_Hsien_Loong_at_Opening_of_IM_Flash_Singapore_s_Nand_Flash_Wafer_Fab.html

29 http://www.edb.gov.sg/content/edb/en/industries/industries/electronics.html

market[30]. Electronics is the major industry underpinning Singapore's economic growth, contributing 33% of the city-state's manufacturing value-added. In line with this, Singapore's Economic Development Board (EDB), the lead government agency for planning and executing strategies to enhance Singapore's position as a global business centre, aims to develop Singapore into a world-class electronic manufacturing hub with end-to-end R&D capabilities.

In turn, Singapore's semiconductor industry is the fastest growing segment of its electronic cluster, expanding 64% in 2010. In 2009, Singapore accounted for 11.2% of the global semiconductor output, and over the last 10 years, Singapore's semiconductor industry has consistently outpaced global industry growth. According to a report by the EDB, Singapore's semiconductor industry posted a nominal growth of 49.8%, outpacing the global semiconductor industry's 32.5% growth in 2010[31].Today, there are 14 operating silicon wafer fabs, 20 assembly and test operations and about 40 integrated circuit (IC) centres. With its business environment and stable political climate, Singapore has proven to be a location of choice for many world-leading companies. It is home to the world's top three wafer foundry companies, three of the top six assembly and test subcontractor companies, nine of the world's top ten fables semiconductor companies, and the top three hard disk drive manufacturers and top five electronics manufacturing services (EMS) providers worldwide.

There are approximately 230 semiconductor companies operating in Singapore, with about 40,000 employees, of whom 4,600 are R&D engineers. In turn, the Singapore Semiconductor Industry Association (SSIA) is a non-profit organisation which aims to bring semiconductor industry players alongside academia and government agencies to support and facilitate the growth of the semiconductor sector and its businesses internationally. Its members include companies and organisations throughout all parts of the complex and comprehensive semiconductor value chain - chip design companies, manufacturers, fabless companies, equipment suppliers, photovoltaic and LED companies, EDA and material suppliers, training and service providers, IP companies, research institutes and academia, as well as individual members. The SSIA currently has a total of 55 members, of which 47 are corporate members.

## *1.4. Report structure*

The remainder of this report is organised as follows. *Chapter 2* presents the key elements of the methodology including cluster selection, approach to data collection and analysis, as well as related key challenges and solutions. *Chapter 3* contains key study findings and offers answers to key analytical questions. *Chapter 4* presents detailed policy recommendations. Finally, *Annex A* offers a comprehensive overview of employed research questions, and *Annex B* contains the questionnaire used for the public consultation.

30 http://www.edb.gov.sg/content/edb/en/industries/industries/electronics.html
31 http://sbr.com.sg/building-engineering/commentary/greener-future-through-innovation-today

# 2. Methodology

The current chapter presents the key elements of the study methodology, specifically the study design, key activities of each stage, as well as the challenges and solutions of data collection and analysis.

## 2.1. Study dimensions

As mentioned in Chapter 1, the objective of the study was to identify and validate a broad set of *measures* that are required to create, expand and keep semiconductor clusters in Europe competitive. The term 'measures' here can be operationalised into specific dimensions presented in Table 2-1 which are relevant for the development of the semiconductor industry. The study dimensions form a theoretical framework of the study and determine the structure of data collection and analysis.

The study focused on the following seven dimensions:

(1) Policy measures and incentives such as State Aid, tax incentives, favourable trade conditions, pre-commercial public procurement, access to finance, public-private partnerships and other means;
(2) R&D&I capacities in Member States and regions and overall in Europe;
(3) Effect of innovation policy and industrial policy regimes;
(4) Technology transfer from research organisations and universities to companies in a nanoelectronics cluster and between nanoelectronics clusters;
(5) Technology transfer between the nanoelectronics manufacturing companies and different application customers;
(6) Clustering models for different types of activities world-wide; *and*
(7) Potential for new clusters or further networking.

Each dimension is elaborated in more detail in the table below.

TABLE 2-1: Study dimensions

| *Description* |
|---|
| **1 Policy measures and incentives** |
| **1.1 State Aid**<br>State aid can be defined as an advantage in any form whatsoever conferred on a selective basis to undertakings by national public authorities. The EC Treaty pronounces the general prohibition of State Aid. Under some circumstances, however, government interventions are necessary for a well-functioning and equitable economy. Therefore, the Treaty leaves room for a number of policy objectives for which State Aid can be considered compatible. By complementing the fundamental rules through a series of legislative acts that provide for a number of exemptions, the European Commission has established a system of rules under which State Aid is monitored and assessed in the European Union[32].<br>Examples of State Aid include[33]:<br>• Grants to firms for investment, R&D, employee training, etc.; |

[32] http://ec.europa.eu/competition/state_aid/overview/index_en.html
[33] http://www.stateaidscotland.gov.uk/state_aid/

| *Description* |
|---|
| • Loans and guarantees below market rates;<br>• Free or subsidised consultancy advice;<br>• Cash injections to and writing off losses of public enterprises;<br>• Sale or lease of public land or property at discounted rates;<br>• Contracts not open to competitive tendering;<br>• Discretionary deferral of or exemption from tax, social security and other payments to the state;<br>• Legislation to protect or guarantee market share;<br>• Funding/cash injections to non-profit social enterprises, community companies and some charities; *and*<br>• Public funding of privately owned infrastructure. |
| **1.2 Tax incentives**<br>Tax exemption refers to being free from, or not subject to, taxation by regulators or government entities. A tax exempt entity can be excused from a single or multiple taxation laws. Governments often use tax exemption to encourage investments[34].<br>The presence of multiple tax incentives is possible. For example, R&D tax credits (RTCs) are introduced to promote research and innovation in which the industry takes an active part. Similar to other tax incentives, a company must have taxable profits in order for the support to have any value. As a result, the precise value of RTC is somewhat unpredictable. In recognition of this, in some countries (such as France), schemes have been designed to minimise the problem: the tax credit always remains refundable. For example, the credit allows innovative SMEs without profit to receive a cash payment after one year, while for other companies this happens after three years[35]. |
| **1.3 Favourable trade conditions**<br>An example of favourable trade conditions is the presence of Free Trade Agreements or FTAs. FTAs refer to agreements between two or more countries to establish a free trade area where commerce in goods and services can be conducted across their common borders, without tariffs or hindrances but (in contrast to a common market) capital or labour may not move freely. Member countries usually impose a uniform tariff (called common external tariff) on trade with non-member countries[36]. |
| **1.4 Pre-commercial public procurement**<br>Pre-commercial procurement is an approach for procuring R&D services which enables public procurers to[37]:<br>• share the risks and benefits of designing, prototyping and testing new products and services with the suppliers, without involving state aid;<br>• create the optimum conditions for wide commercialisation and take-up of R&D results through standardisation and/or publication; *and*<br>• pool the efforts of several procurers.<br>By acting as technologically demanding first buyers of new R&D, public procurers can drive innovation from the demand side. This enables European public authorities to innovate the provision of public services faster and creates opportunities for companies to take international leadership in new markets[38]. |
| **1.5 Access to finance**<br>Venture capital (VC) is financial capital provided to early-stage, high-potential, high risk start-up companies. A typical venture capital investment occurs after the seed funding round as part of the growth funding round in the interest of generating a return through an eventual realisation event, such as an initial public offering (IPO) or trade sale of the company.<br>Semiconductor start-ups in general find it hard to raise VC money due to several industry-specific characteristics. The cost of designing and manufacturing a new chip is rising as transistors reduce in size, and often an investment of about 10 to 50 million EUR is needed just to find out if the design is going to work. The sale of semiconductor start-ups, in turn, generally pays a lower multiple than a software or Internet company with similar revenue and growth. As a result, venture capitalists have to take on more risk with less potential upside. Besides the risk that the product will not work or that it will be too expensive to build, there is a high risk that start-ups, even those which meet their milestones, will not be able to get funded. These reasons makes investors even more sceptical thereby causing additional difficulty in attracting funds. |

[34] http://www.investopedia.com/terms/
[35] ESIA 2008 Competitiveness Report
[36] http://www.businessdictionary.com/definition/free-trade-agreement.html
[37] http://ec.europa.eu/information_society/tl/research/priv_invest/pcp/index_en.htm
[38] COM(2007) 799 Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe

| Description |
| --- |
| **1.6 Public-private partnerships**<br><br>Public-private partnerships (PPPs) are increasingly gaining importance as vehicles to finance public infrastructure across Europe. In its Green Paper on PPPs, the European Commission suggested the following elements to characterise a PPP[39]:<br><br>• The relatively long duration of the relationship, involving cooperation between the public partner and the private partner on different aspects of a planned project;<br>• The method of funding the project, in part from the private sector, sometimes by means of complex arrangements between the various players;<br>• The important role of the economic operator, who participates at different stages in the project (design, completion, implementation, funding); *and*<br>• The distribution of risks between the public partner and the private partner, to whom the risks generally borne by the public sector are transferred. |
| **1.7 Other means**<br><br>Other means may include:<br><br>o Harmonisation of ICT standards and standardisation processes;<br>o Single market regulation;<br>o Market surveillance on unsafe products;<br>o Intellectual property regulation;<br>o Bonuses for cross border cooperation and dissemination;<br>o Enhancing semiconductor workforce;<br>o Eliminating new tariffs on emerging semiconductor devices;<br>o Advancing environmental initiatives and trade liberalisation;<br>o Upholding strong anti-dumping laws and effective anti-dumping remedies;<br>o etc. |
| **2 R&D&I capacities in Member States and regions and overall in Europe** |
| R&D&I capacities include:<br><br>o The presence of regional integrated expert centres, technology-transfer centres and innovation centres forming regional intellectual and R&D&I bases;<br>o The availability of innovation services, SME consultancy, education and training;<br>o The presence of large companies;<br>o The presence of strong innovative SME base;<br>o etc. |
| **3 Innovation policy and industrial policy regimes** |
| Examples of innovation policy and industrial policy measures:<br><br>o Promoting and leading international cooperation;<br>o Encouraging the creation and expansion of new firms in high-technology sectors, calling on financial markets and venture capital investment capabilities;<br>o Leveraging the 'institutional' capabilities academia (universities and research institutes) and regional and local government bodies provide to extend and exploit their research infrastructures such as science parks, incubators, venture partnering;<br>o Creating incentives for clusters;<br>o etc. |
| **4 Technology transfer from research organisations and universities to companies in a nanoelectronics cluster and between nanoelectronics clusters** |
| Examples of measures stimulating technology transfer from research organisations to companies:<br><br>o Funds for labour-mobility work;<br>o Allowing part-time positions;<br>o Public funds for collaborative research;<br>o Revenue sharing rules;<br>o Funds for entrepreneurship; |

[39] COM(2004) 327 final: Green Paper on public-private partnerships and Community law on public contracts and concessions, European Commission

| Description |
|---|
| o University patent legislation;<br>o etc. |
| **5 Technology transfer between nanoelectronics manufacturing companies and different application customers** |
| Examples of measures stimulating technology transfer between companies:<br>o Direct business alliances or partnerships between semiconductor companies and application companies;<br>o Centres of excellence based on common interests and complementary capabilities;<br>o etc. |
| **6 Clustering models world-wide** |
| Possible roles of a cluster organisation:<br>o Match-maker between academia and industry;<br>o Facilitator of networking events;<br>o General information point on the cluster (including a directory of participating companies and other organisations);<br>o etc.<br>Other relevant characteristics of a cluster organisation:<br>o Size;<br>o Organisational structure;<br>o Type of provided services;<br>o Strategy and focus (for example, exclusive focus on semiconductor industry versus multi-sectoral orientation); *and*<br>o Funding and membership model. |
| **7 Potential for new clusters or further networking** |
| Clusters tend to emerge in different ways[40]:<br>(1) *Spontaneous clusters*: genesis is based on a spontaneous agglomeration of key enabling factors without direct commitment of public actors. The factors that play a role in the appearance and enlargement of spontaneous clusters are:<br>o Availability of the strong scientific base;<br>o Effective exploitation mechanisms of scientific research, especially by means of effective technology transfer mechanisms and a strong diffusion of the entrepreneurial culture among scientists and researchers;<br>o Existence of multiple innovative funding mechanisms (for example, seed funds, angel capital, venture capital, etc.); *and*<br>o The presence of a well-defined legal framework.<br>(2) *Policy-driven clusters*: formation is a consequence of active efforts and policies of governmental agencies aimed at cluster development. The types of policies that are usually implemented can be divided into:<br>o Industry restructuring policies: emerge as a reactive response to an industrial crisis; *and*<br>o Industry development policies: applied for a focused establishment of an industry sector.<br>(3) *Hybrid clusters*: where features of both of the above cluster types are observed. |

## 2.2. Research questions

Table 2-2 provides an overview of the research questions the current study aimed to answer. As can be seen from the table, the research questions are structured around the abovementioned seven study dimensions.

TABLE 2-2: Overview of research questions

| *Study dimensions* | *Research questions* |
|---|---|
| **1. Policy measures** | *1.1 What are the motives for the* ***State Aid*** *in semiconductors? How important is the State Aid relative to other influential factors with regard to international competitiveness? What best practices can be found* |

[40] Chiesa V., Chiaroni, D. (eds.) (2005) Industrial Clusters in Biotechnology: Driving Forces, Development Processes and Management Practices. London, Imperial College Press

| *Study dimensions* | *Research questions* |
|---|---|
| **and incentives** | *outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *1.2 What are the motives for the **R&D tax incentives** in semiconductors? How important are tax incentives relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *1.3 What are the motives for the **favourable trade conditions** in semiconductors? How important are favourable trade conditions relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *1.4 What are the motives for the **pre-commercial public procurement** for semiconductors? How important is pre-commercial public procurement relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *1.5 How important is **access to finance** (seed capital, venture capital, loans) relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *1.6 What are the motives for forming **public-private partnerships** for semiconductors? How important are public-private partnerships relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *1.7 How important are **other policy** measures and incentives relative to the abovementioned factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| **2. R&D&I capacities** | *2.1 What are the **current R&D&I capacities** in EU Member States and regions in the field of semiconductors?* |
| | *2.2 What **adjustments in framework conditions** would allow for boosting the current R&D&I capacities in Europe? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *2.3 What **unique demands** are put on European companies maintaining R&D investments at high levels in a highly globalised economic environment? How can policy measures and incentives help companies meet these demands?* |
| **3. Effect of innovation policy and industrial policy regimes** | *3.1 What innovation policy and industrial policy measures are needed to effectively support **R&D&I efforts in semiconductors**? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *3.2 What innovation policy and industrial policy measures are needed to effectively support **semiconductor manufacturing**? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *3.3 What innovation policy and industrial policy measures are needed to effectively support **the creation of new market opportunities** for semiconductors? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *3.4 What innovation policy and industrial policy measures are needed to effectively **attract a highly skilled workforce** and encourage more students to complete technological studies? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *3.5 What are the **differentiated effects** of the innovation policy and industrial policy regimes on different types of semiconductor firms?* |
| **4. Technology transfer from research organisations and universities to companies** | *4.1 What policies and measures are needed to effectively support technology transfer from universities to industry at the **individual level** (scientists)? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| | *4.2 What policies and measures are needed to effectively support technology transfer from universities to industry at the **institutional level** (universities)? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| **5. Technology** | *5.1 To what extent do the current clustering models of semiconductor clusters **incorporate end-user*** |

| *Study dimensions* | *Research questions* |
|---|---|
| **transfer between nanoelectronics manufacturing companies and different application customers** | ***industries***? |
| | *5.2 What policy measures can help semiconductor companies* ***get access to, and be in proximity of, end-user industries****? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| **6. Different clustering models for different types of activities worldwide** | *6.1 What* ***clustering models*** *of semiconductor clusters can be identified?* |
| | *6.2 What is the* ***role of cluster organisations*** *in semiconductor clusters? What are the specific characteristics of cluster organisations in these clusters (for example, size, organisational structure, type of provided services, strategy and focus, funding etc.)? What are the key differences in the way clusters are organised within and outside the EU?* |
| | *6.3 What are the* ***key differences*** *between clustering models of semiconductor clusters in Europe and outside Europe (Asia, US)?* |
| | *6.4 What* ***policy measures*** *are effective in supporting the identified clustering models? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?* |
| **7. Potential for new clusters or further networking** | *7.1 Where in Europe do* ***new semiconductor clusters*** *currently emerge or are likely to emerge? What are the key emerging semiconductor clusters outside Europe?* |
| | *7.2 What is the* ***potential of further networking*** *among European and between European and non-European semiconductor clusters? For which* ***stages of the value chain/types of semiconductor companies*** *is global networking particularly crucial? What policy measures can effectively stimulate such networking?* |

## *2.3. Three-stage analysis*

The current study implied three-stage analysis consisting of the following distinct stages (see Figure 2-1):

(1) Cluster-level case study analysis;
(2) Cross-case analysis; *and*
(3) Synthesis and extraction of evidence-based policy recommendations.

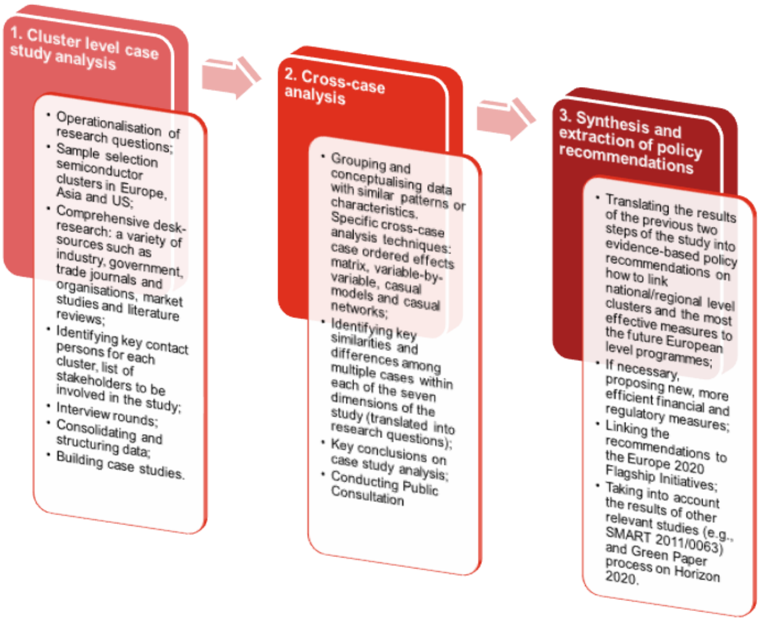


FIGURE 2-1: Three-stage analysis

During the first stage, a rigorous case study analysis was conducted for individual clusters included in the sample. This stage began with the operationalisation of the abovementioned research questions into sub-questions/items that are observable at the cluster level. These sub-questions/items were crucial for determining the type of data sources that needed to be employed in the current study, as well as the type of stakeholders to be approached, and tools and techniques to be used. We then developed a detailed case study protocol including fieldwork procedures, case study questions and guidelines for case study reports. We also developed tools, procedures and formats for data collection. For each cluster, key contact persons were identified, and a list of relevant stakeholders (including their contact details) was prepared. The actual data collection then took place, involving desk research and interview rounds with a selection of stakeholders. The final steps of the first stage involved consolidating and structuring the data for each case and preparing detailed case study reports for each cluster from the sample. The key outputs of the first stage of the analysis were detailed case study reports.

After a thorough examination of individual clusters, the second stage of the study implied cross-case analysis and generalisation of conclusions (detection of trends observable in various cases). This stage in essence related to the identification of key similarities and differences among multiple cases within each of the seven dimensions of the study which were translated into specific research questions. The key activities included grouping and conceptualising data with similar patterns or characteristics by means of specific cross-case analysis techniques: case ordered effects matrix, causal models and causal networks. In the end of the second stage, based on the results of the cross-case analysis, we identified a list of framework conditions, policy measures and incentives that prove to be effective in creating, expanding and keeping nanoelectronics clusters competitive. These framework conditions and measures were then validated by a broader group of stakeholders by means of a public consultation.

The final stage of the analysis implied translating the results of the first two stages into policy recommendations for linking national/regional level clusters and the most effective measures to future European level programmes such as Horizon 2020 and others.

In the remainder of this chapter, we will elaborate on each of the stages in more detail.

## 2.4. Cluster-level case study analysis

The first stage of the study involved a detailed case study analysis for individual clusters included in the sample.

### 2.4.1. Operationalisation of research questions at cluster level

The study aimed to derive evidence-based policy recommendations based on the results of a multiple case study analysis, where each case represented a semiconductor cluster from the sample. Data from the clusters thus needed to be synthesised and analysed at a higher aggregation level (cross-case analysis). The first step implied the translation of the general research questions (cross-case level questions, see Section 2.2) into research sub-questions to be answered at the level of individual clusters. *Annex A* provides an overview of cluster-specific research sub-questions that we analysed within each of the seven study dimensions (see Section 2.1). In this Annex table, we also provide examples of secondary data sources and key stakeholder groups, as well as relevant data collection tools and techniques.

### 2.4.2. Designing a case study protocol

The next step of our methodology was the development of the case study protocol (CSP). The protocol included the following sections:

- *An overview of the case study project* – project objectives, case study issues, and presentations about the topic under study;
- *Field procedures* – reminders about procedures, credentials for access to data sources, and location of those sources;
- *Case study questions* – the questions that we needed to keep in mind during data collection; *and*
- *A guide for the case study report* – the outline and format for the report.

A CSP is a set of guidelines that were used to structure and govern the development of individual cases. The protocol outlined the procedures before, during and after a case study. In addition, a case study protocol ensured uniformity in data collection and analysis. Apart from procedures, a CSP also contained the research instruments that were used to collect data during the study.

### *2.4.3. Drawing a sample of clusters*

As mentioned above, the current study is based on the analysis of four European and four non-European clusters. The following four European clusters were selected:

- Grenoble cluster (Grenoble, France);
- Silicon Saxony (Dresden, Germany);
- DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium); *and*
- Silicon South West (South West England, UK).

Four non-European clusters include:

- Silicon Valley (San Francisco Bay Area, US);
- Hudson Valley Research Park (IBM Fishkill) and Albany Nanotech Complex (Albany, US);
- Zhongguancun (Beijing, China); *and*
- Hsinchu Science and Industrial Park (Hsinchu, Taiwan).

Below we elaborate on the key selection criteria. These include the following:

(1) ***Geographical location***. For a representative and geographically well-balanced sample, four European and four non-European clusters needed to be selected. As framework conditions and the relevant policy measures and incentives do not considerably differ for semiconductor clusters within one country, for the purpose of obtaining more fruitful findings, we aimed for a higher diversity of countries instead of taking various clusters from one country. As such, whenever possible, we aimed to include not more than one cluster from a country, unless the respective clusters within one country greatly differ in some/all of the study dimensions. Such an approach allows for obtaining a broader palette of policy measures and initiatives from different contexts and thus enriches the base for developing evidence-based policy recommendations.

(2) ***Specialisation***. The current study exclusively analyses semiconductor clusters. Therefore, to be included in the sample, the key specialisation of clusters had to refer to Integrated Circuit (IC) technologies and manufacturing; semiconductor manufacturing equipment and materials; design of ICs (related to manufacturing); as well as semiconductor-related R&D infrastructures and public research. We also consulted NACE and NUTS databases[41] in order to describe the main interactions of the industrial sector and geographies.

(3) ***Number of firms in the cluster***. To survive and prosper in a turbulent, chaotic and highly unpredictable environment, clusters require a strong industrial base. When analysing the number of firms in the cluster, we also took into account the diversity of companies with regard to their size and position in the value chain.

[41] NACE (Nomenclature statistique des activités économiques dans la Communauté Européenne) is the European industry standard classification system consisting of a 6 digit code, NUTS (nomenclature d'unités territoriales statistiques) is a geographical coding standard for referencing the administrative divisions of countries on three different levels. Some countries have added compatible levels to NUTS themselves.

(4) ***The presence of large companies in the cluster***. Large semiconductor companies play an important role in cluster development. Large firms act as miniature innovation systems in their own right, providing incubation space to employees, financing their own start-ups, offering technical expertise, product specifications and initial markets. In addition, large firms also provide a steady flow of trained people which small innovating firms can hire, and can share expertise with the supply chain[42]. Large firms can play a catalytic role in a number of ways. First of all, they create a critical mass of experienced managers and workers. Secondly, they can provide a customer and supplier base. Thirdly, large companies provide ideal conditions for high technology firms to grow and develop. Finally, large companies have multiplier effects in terms of a region's local economy for materials and services (these can range from university graduates to office supply services to the production of raw materials). Therefore, large firms can play a key role in diffusing knowledge and technology to SMEs, nurturing future entrepreneurs and inspiring spin-outs.

(5) ***Share of employment in the region***. Employment growth is one of the key indicators of cluster performance. Here, specific issues arise regarding the necessary regionalisation of statistical data. This type of data is often either not available at regional level, or the regions defined for administrative purposes and used for statistical purposes do not correspond to the functional regions considered for the development of the semiconductor sector[43]. As such, data limitations restrict the use of employment data to evaluate clusters. This creates a certain bias in measures towards employment-intensive clusters[44], and discriminates against capital- or knowledge-intensive cluster categories such as nanoelectronics. For those clusters where regional statistics are not available, it is preferable instead to use data on innovation, productivity, revenue or value-added, which shift the balance in favour of capital- or knowledge-intensive cluster categories.

(6) ***Historical strength and reputation of the cluster***. Finally, the historical strength and reputation of the cluster were taken into account. We included in the sample both semiconductor clusters with a long history and extensive track record, as well as clusters which have 'popped up' recently and demonstrate rapid development. The analysis of the second group of clusters is particularly expected to produce fruitful results, as their rapid development is more likely to be related to adjusted framework conditions and recent policy measures and initiatives.

The final selection of four European and four non-European clusters was made by the research team *in close cooperation with the Commission* based on the availability of information on specific clusters.

### *2.4.4. Identifying key stakeholders*

We first gathered and analysed the relevant Internet-based resources related to the selected cluster. This helped us to identify potential stakeholders and their connection to the cluster in question.

[42] A Practical Guide to Cluster Development. A Report to the Department of Trade and Industry and the English RDAs by Ecotec Research & Consulting

[43] The concept of clusters and cluster policies and their role for competitiveness and innovation: Main statistical results and lessons learned. The Commission Staff Working Document SEC (2008) 2637

[44] European Cluster Observatory: Cluster Evaluation

In the beginning of the stakeholder identification procedure, we established contact with the official representatives of each cluster from the sample if it was an organised initiative, i.e., a cluster organisation was present. It proved to be highly beneficial to closely cooperate with central cluster representatives as they have a comprehensive overview of cluster members, their contact details and direct access.

The initially developed list of stakeholders to be engaged in the study had then to be prioritised. For that purpose, we closely cooperated with the key contact persons for each cluster. Once the stakeholders were chosen, we developed a contact list with the stakeholders' names, positions, affiliated organisations, phone numbers and emails.

### *2.4.5. Data collection*

Data collection was performed using multiple sources of evidence and thus following a triangulation rationale.

The main sources of data that were employed for case study analysis include:

- ***Desk research***. The objective of the desk research was to develop a comprehensive overview of the information already available from the secondary sources. Desk research resulted in preliminary factsheets for each of the clusters in the sample; *and*
- ***Interviews***. Based on the results of the desk research, we identified a set of issues that required additional clarification and were of particular importance for the development of effective evidence-based policy recommendations. Interviews were focused on going in-depth within a selection of topics.

Below we elaborate on each of those data sources in more detail.

#### *2.4.5.1. Desk research*

Multiple sources have been mobilised to develop a comprehensive literature base for each of the case studies:

- ***Own sources of PwC semiconductor industry practice:***

  Over the past six years, the PwC semiconductor industry practice has developed and published several studies on key issues affecting semiconductor companies. Recent studies include:

  - The Impact of China on the Semiconductor Industry;
  - Venture Capital Trends in the Semiconductor Industry;
  - Effective Tax Rate Analysis: Semiconductor Industry;
  - Semiconductor Financial Benchmarking Analysis –Public Equipment Companies;
  - Compensation Practices of Fabless Semiconductor Companies;
  - Public Company Segment Disclosures;
  - Benchmarking Semiconductor Critical Accounting Policies;
  - Pro Forma Reporting in the Semiconductor Industry;
  - Semiconductor Financial Benchmarking Analysis - Fabless Companies;

- Semiconductor Financial Benchmarking Analysis –Public Device Manufacturers;
- Analysis of SEC Comment Letters in the Semiconductor Industry; *and*
- Uncovering excellence in cluster management.

- ***Semiconductor industry overviews and publications on the websites of semiconductor industry associations of the relevant countries/regions, for example***:
    - European Semiconductor Industry Association (ESIA) at http://www.eeca.eu/esia/
    - Semiconductor Industry Association in the United States (SIA) at http://www.sia-online.org/
    - China Semiconductor Industry Association (CSIA) at http://www.csia.net.cn/wsc/AboutCSIA.asp/
    - Taiwan Semiconductor Industry Association (TSIA) at http://www.tsia.org.tw/Eng/
    - Japan Electronics and Information Technology Industries Association (JEITA) at http://www.jeita.or.jp/english/
    - Korea Semiconductor Industry Association (KSIA) at http://www.ksia.or.kr/eng/main/
    - India Semiconductor Association (ISA) at http://www.isaonline.org/
    - Global Semiconductor Alliance (GSA) at http://www.gsaglobal.org/resources/index.asp/

- ***Relevant communications and regulations of the respective countries/regions, for example:***
    - State Aid regulations of the respective countries;
    - European Commission Trade agreements at http://ec.europa.eu/trade/
    - United States Trade agreements at http://www.ustr.gov/trade-agreements;
    - Pre-commercial public procurement regulations of the respective countries;
    - COM(2007)799 Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe;
    - "US defence R&D spending: an analysis of the impacts", EURAB report, PREST, 2004, quoted in COM(2007)799;
    - GREEN PAPER From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation funding http://ec.europa.eu/research/csfri/pdf/com_2011_0048_csf_green_paper_en.pdf#page=2

- ***Other existing studies and reports, for example:***
    - "Pre-commercial procurement of innovation: A missing link in the European innovation cycle", National IST Research;
    - Directors Forum Working Group on Public Procurement in support of ICT Research and Innovation, March 2006 at ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/pcp/precommercial-procurement-of-innovation_en.pdf
    - KPMG 2010 "Asia Pacific Indirect tax country guide";
    - ESIA 2008 Competitiveness report;
    - "Exploring the potential of ICT Components and Systems Manufacturing in Europe";
    - First interim evaluation of the ARTEMIS and ENIAC Joint Technology Initiatives, European Commission, 2010;

- ENIAC Annual activity reports and work programmes at http://www.eniac.eu/web/documents/general.php
- Sectoral Innovation Foresight Electrical and optical equipment Interim Report, ELECTRA 2008;
- 2010 EU Industrial R&D Investment Scoreboard;
- "Vision, mission and strategy: R&D in European Micro- and Nanoelectronics", AENEAS report at http://www.aeneas-office.eu/web/downloads/aeneas/vms_final_feb2011_1.pdf
- "Incentives to Encourage Electronics Manufacturing in Europe", VDI/VDE-IT 2011 at http://cordis.europa.eu/fp7/ict/micro-nanosystems/docs/ictman/ict-man-objective-5_en.pdf
- Chips with everything. Lessons for effective government support for clusters from the South West semiconductor industry, http://www.nesta.org.uk/library/documents/Semiconductorsv10.pdf
- SMART 2011/0063 ("Strategies for innovative and effective ICT Components & Systems Manufacturing in Europe").

The results of the desk-research formed the basis for the preparation of the preliminary fact sheets for each case study, which in turn were completed during the next stages of the study. The fact sheets contained the main characteristics of the cluster (for example, cluster name, region, country, establishment year, category, number of companies, key members, specialisation/key areas of activity), as well as the data on each of the seven dimensions of the study.

#### *2.4.5.2. Interviews*

Based on the results of the desk research, we identified a set of issues that required additional clarification and were of particular importance for the development of effective evidence-based policy recommendations. Interviews were thus focused on going in-depth within a selection of topics, and were of semi-structured nature.

In total, we interviewed 32 stakeholders. In terms of the duration of the interviews, we strived towards 1.5 to 2 hours per interview. During the interview process, the so-called *snow-ball* principle was used. Each conducted interview enlarged a base for discussion for further interviews. As a result, the initial fragments of information were gradually expanded and integrated into an overall picture of the considered case. The sequence in which interviews were conducted followed the logic of who can contribute most at the different stages of our investigation.

The interview questionnaire included the introductory section which the interviewer communicated to each of the stakeholders. This introduction stated the objectives of the interview, identified who was collecting the information, and explained what would be done with the information.

### *2.4.6. Preparing cluster reports*

The final step of the first stage included the preparation of individual case study descriptions for each of the clusters from the sample based on the results of the desk research and in-depth interviews. The structure of these descriptions was built around the key research questions of the study. Such approach ensures high comparability of data and thus allows for efficient cross-case analysis.

## 2.5. Cross-case analysis

After a thorough examination of individual clusters, the second stage of the study implied a cross-case analysis and detection of trends observable in various cases. The essence of this stage referred to the identification of key similarities and differences across multiple cases within each of the seven dimensions of the study which were translated into specific research questions. Drawing and verifying conclusions required systematic understanding of the case study using a logical chain of evidence and maintaining theoretical coherence by tactics such as identifying themes and patterns, establishing plausibility, counting and data clustering.

### 2.5.1. Grouping and conceptualising data

Cross-case analysis divided the data by type (i.e., study dimensions) across all cases investigated. When a pattern from one data type was corroborated by the evidence from another, the finding was considered to be stronger. When evidence conflicted, deeper probing of the differences was performed to identify the cause or source of conflict. In all cases, the research team used the evidence to produce analytic conclusions answering the original "what" and "how" research questions. We aimed to employ the clustering technique by means of grouping and then conceptualising data with similar patterns or characteristics.

### 2.5.2. Deriving a list of framework conditions, policy measures and incentives

Based on the results of the cross-case analysis, we identified a preliminary list of framework conditions, policy measures and incentives that prove to be effective in creating, expanding and keeping nanoelectronics clusters competitive. The identified measures were structured around the key study dimensions, as well as geographically (European versus non-European), and the assessment of the applicability of the successful non-European measures to the European context was performed. An important consideration at this stage was that measures which work in one setting would most probably not work in another, if underlying conditions are considerably different. Given a highly complex nature of the topics examined by the study, various additional factors needed to be taken into account to assess the applicability and feasibility of measures from other contexts (see also Section 2.8 on potential risks and challenges).

### 2.5.3. Public consultation

The findings from cross-case analysis were complemented by the results of an open public consultation (hereafter "Consultation"). The Consultation aimed to involve the key stakeholder groups of the semiconductor industry in Europe, and specifically:

- ***Industry representatives***: materials manufacturers; equipment manufacturers; chip manufacturers (IDMs, fabless, foundries, testing, packaging, etc.); manufacturers of other electronic components, application manufacturers etc.;

- ***Representatives of universities and research institutes***: stakeholders from academia including heads of laboratories/research departments/research institutes involved in semiconductor research; *and*

- ***Public authorities***: representatives of ministries of education, science, research; ministries of economy, industry and trade etc., as well as several types of national advisory organisations and boards on, for example, innovation, science, R&D; and regional and European public actors.

The instrument used for the Consultation was a questionnaire designed by PwC and validated by the Commission. A full version of the questionnaire is available in *Annex B* of this report.

#### *2.5.3.1. Duration, technical solution and dissemination*

The Consultation was launched on 31 July 2012, and was open for 1.5 months until 15 September 2012.

As a technical solution for the Consultation, the *Interactive Dialogues*[45] (ID) platform was used. The questionnaire could be accessed via an Internet link which was placed on the Commission's website[46]. Additionally, the information on the Consultation was disseminated among the members of SEMI Europe[47] and the European Semiconductor Industry Association (ESIA)[48].

#### *2.5.3.2. Response rate*

In total, 132 respondents familiarised themselves with the content of the Consultation, and 37 respondents provided their answers. Out of 37 respondents, the majority were industry players (56.8%), particularly those specialising in semiconductor manufacturing and semiconductor design (27% and 21.6% of respondents respectively). The second biggest contributor group (27%) was made up of university and research organisations. Policy makers also contributed to the survey, comprising 5.4% of respondents. Other respondents included associations representing European R&D semiconductor players, a cluster organisation for high-tech companies and knowledge institutes, and IT-related companies. There were no respondents representing investors or industry players specialising in semiconductor materials.

#### *2.5.3.3. Challenges and limitations of public consultation*

Several challenges and limitations can be identified in the process of the Consultation. These challenges and limitations are listed below.

*Relatively short duration of the Consultation, partially covering a holiday period*: Due to time constraints of the study, the Consultation had to be launched during a holiday period. To minimise the consequences for the response rate, there was a clear need to allow the respondents to access

[45] http://www.interactivedialogues.com
[46] http://cordis.europa.eu/fp7/ict/components/public-consultation_en.html#public_consultation11
[47] http://www.semi.org/eu/
[48] https://www.eeca.eu/

the Consultation after the summer. As a result, the questionnaire was open for additional two weeks in September.

*Highly specific nature of questions combined with broad scope of the Consultation*: Not all respondents who provided answers to the Consultation completed the Consultation in full. In many cases, the respondents chose to provide their inputs to certain questions only, and not to the whole Consultation. The discrepancy between the number of people who opened the Consultation and the number of people who actually provided their inputs, as well as the selectivity of respondents in answering only certain questions, can be explained by a highly specific nature of the questions and a broad scope of the Consultation. Both factors reduce a chance that a single respondent would be able and/or willing to comment on *all* the questions.

## 2.6. Synthesis and extraction of evidence-based policy recommendations

As the key output of the study, we developed policy recommendations on how to link national/regional level clusters and the most effective measures to future European level programmes such as Horizon 2020 and others. The study identified measures that can be adopted at European level. The recommendations refer to the Europe 2020 Flagship Initiatives "An Industrial Policy for the Globalisation Era", "Innovation Union" and "Digital Agenda for Europe". The recommendations take into account the outcomes of the Green Paper process on Horizon 2020. The recommendations also elaborate on synergy that can effectively be generated by links between regional/national and European level support. Finally, the recommendations take the results of other relevant studies such as "Strategies for innovative and effective ICT Components & Systems Manufacturing in Europe" (SMART 2011/0063) into consideration.

## 2.7. Validation workshop

The key study findings and recommendations have been validated during a workshop held at the Commission's premises in Brussels on 6 December 2012. The objective of the workshop was to provide the relevant stakeholders and experts a platform for discussion on the key outputs of the study in order to validate those outputs, and to collect stakeholder views on current and future developments in the policy areas relevant for the semiconductor clusters in Europe. The workshop was attended by the key representatives of DG CONNECT, as well as of the European semiconductor industry. The results of the workshop are incorporated into the current version of the Report.

## 2.8. Challenges and solutions in data collection

Several practical challenges were encountered during data collection activities. These challenges included availability of data, diversity of opinions, language barriers, communicating across different time zones, delayed responses from stakeholders, stakeholders that were sceptical about the study and hesitant to provide information, and stakeholders that were unable to participate for specific reasons. We attempted to overcome these challenges by working in a flexible fashion, adapting the methods and working arrangements, and extensively communicating the nature of the study and its potential benefits to the stakeholders. Below we elaborate on these challenges and solutions in more detail.

### 2.8.1. Availability of data

To prevent having insufficient quality and volume of information available on a specific case, the overall process of data collection was designed to be iterative in nature. Besides undertaking comprehensive desk research, the process involved initial interaction between the research team and the key contact persons for each case, followed by a series of in-depth interviews with the key stakeholders. Furthermore, to mitigate risks in this area, our approach entailed the institution of a close working relationship between the research team and the proposed PwC focal points within the regions (whenever necessary). This approach facilitated an ongoing two-way flow of information between the team and the focal points so that the approach to addressing information deficiencies is fully informed.

### 2.8.2. Diversity of opinions

When collecting information on a particular issue, we often had to face diversity of opinions, with different (groups of) stakeholders often having different views on the same issue. In some cases, a certain policy measure was suggested as a good practice by one stakeholder group, and at the same time heavily criticised by another. The situation is complicated by the fact that it is not always possible to prove a direct causal link between a certain policy measure and the development of the semiconductor industry (for example, by means of an ex-post evaluation), so judgments have to be based on stakeholder opinions. To deal with this challenge, we aimed at holding on to the facts as much as possible, and clearly indicating the subjective nature of a certain judgement whenever it represented someone’s personal opinion. Our objective was to present different opinions without choosing sides, and then to draw conclusions based on the factual analysis.

### 2.8.3. Language barriers

When working on clusters from East Asia, we encountered language barriers when trying to establish contact with key contact persons as well as during interviews with stakeholders. Some representatives of organisations that we targeted were not sufficiently proficient in English to respond to our request. This made it challenging for us to explain the nature of our study, to convince key contact persons to participate in our study, and to conduct interviews with key stakeholders. To overcome this challenge, we added additional members to our team who were proficient in the language of our respondents (for example, Chinese). The questions were translated into the relevant language, and communication with the stakeholders was maintained via these additional team members. This approach allowed us to obtain sufficient information for detailed case study descriptions.

### 2.8.4. Communicating across different time zones

Due to the geographical spread of the analysed clusters (Europe, US, East Asia), it was often necessary to communicate across different time zones. For some cases, this meant that there was hardly any overlap between office hours of the research team and the regular working hours of the interviewees, which limited the window of opportunity for scheduling interviews. In order to tackle this challenge, the research team worked in a flexible manner, extending working days and allowing for irregular working hours. This made it possible for the interviewees to have interviews within their office hours despite significantly different time zones.

### 2.8.5. Delayed responses from key contact persons and other stakeholders

In some cases, contact persons and other stakeholders reacted to our messages in a delayed manner. This had an unfavourable effect on the project planning. In such cases, we used follow-up emails and phone calls. We also strived to make sure that specific individuals were approached by the same member of our research team in every communication effort.

### 2.8.6. Key contact persons that were sceptical about the study and/or hesitant to provide information

In a few cases, the key contact persons were hesitant to participate in the study. This was the case for the Taiwanese semiconductor industry association. The key arguments provided to the research team were that the questions asked were too detailed, and that the respective organisation did not possess the relevant information to provide the answers sought.

## 2.9. Challenges and solutions in data analysis

In this sub-section, we elaborate on challenges and solutions related to data analysis.

### 2.9.1. High complexity of cases

Semiconductor clusters represent highly complex cases. They cover a large variety of actors, relations and interaction channels, each being determined by a partially different set of elements. Furthermore, a weak presence of certain factors may be compensated by a more intense presence of other factors, and it does not yet indicate that certain factors should be considered barriers or enablers of cluster success. In our analysis, the presence of barriers/enablers to the development of a cluster is linked (whenever possible) to specific cluster activities by means of introducing operationalised questions in the desk research and interviews. We also aimed at identifying commonalities among barriers and enablers for all cases in the sample.

### 2.9.2. Sensitivity to certain environments

The development of semiconductor clusters is sensitive to certain environments. Influencing factors may have different effects on the cluster in different parts of the world due to contextual differences (cultural, economic, social, etc.). It is important not only to choose the right level of aggregation, but also to be cautious when judging on good practices across all clusters. When collecting data on individual cases, we gathered additional information on contextual factors that needed to be taken into consideration in order to assess its level of transferability to Europe.

### 2.9.3. Diversity of influencing factors

Key factors influencing the competitiveness of semiconductor clusters are highly diverse. These factors may be mutually strengthening, neutralising or contradictory. Thus, it is difficult to isolate the separate effect of a certain factor. We therefore strived to make an inventory of various influencing factors from all seven study dimensions. The effects of these factors on the competitiveness of clusters must be, however, treated with great care. We also paid attention to a total set of factors (groups of factors) influencing the examined cases, and not only individual factors. Furthermore, some policy measures influence the semiconductor industry without explicitly targeting the industry (for example, trade policy, tax schemes, cluster measures, etc.); the challenge was not to overlook these measures.

### 2.9.4. Time lag effect

There is a time lag in the marginal effects of factors such as framework conditions, public policies and public support services, which vary by country/region and sector. This often makes it difficult to associate changes in general framework conditions with changes in the competitiveness of clusters. Although we aimed at examining the influence of general framework conditions, public policies and public support services on the competitiveness of clusters, any conclusions with regard to causal relationships need to be interpreted with caution.

# 3. Key findings

The current chapter provides an overview of key findings and conclusions from the comparison of European and non-European semiconductor clusters. The presentation of results is structured around the key research questions grouped into the seven study dimensions.

## 3.1. Policy measures and incentives

Policy measures and incentives are reported to have a considerable impact on the competitiveness of the semiconductor industry. They create an environment that can be favourable, neutral or hostile for the industry's development. Below we address seven types of policy measures and incentives: (1) State Aid; (2) tax incentives; (3) favourable trade conditions; (4) pre-commercial public procurement; (5) access to finance; (6) public-private partnerships; and (7) other means.

### 3.1.1. State Aid

As mentioned in *Chapter 2*, State Aid can be defined as an advantage in any form whatsoever conferred on a selective basis to undertakings by national public authorities. Examples of State Aid, among others, include grants to firms for investment, R&D, employee training, etc.; loans and guarantees below market rates; free or subsidised consultancy advice; and public funding of privately owned infrastructure. Below we elaborate on the key findings with regard to this policy measure.

#### 3.1.1.1. The importance of State Aid for the development of the semiconductor clusters

State Aid is reported to be crucial for the development of the semiconductor industry and is suggested to affect the key components of the innovation system such as networks and institutions[49]. State Aid has been an essential factor contributing to the establishment of semiconductor clusters all over the world. The creation of favourable conditions serves to attract firms, human capital and investments into the cluster area. What makes State Aid particularly important for the semiconductor industry is the fact that the industry itself implies high R&D intensity and high (infrastructure-related) capital intensity which can be partially dealt with by means of State Aid. ***It is reported to be one of the key factors determining the decision of semiconductor companies to move to or stay in a certain region***.

Table 3-1 provides an overview of the key findings on State Aid based on the analysis of four European and four non-European clusters. In the reminder of this sub-section, we elaborate on the main conclusions per region (Europe, Unites States and Asia).

[49] Blümel C., Wydra S. (2012) "State Aid Regulation in the Nanoelectronics Innovation System", EU-SPRI 2012 Karlsruhe

TABLE 3-1: Overview of key findings on policy measures and incentives: State Aid

<table>
<tr><th colspan="2">1.1 Policy measures and incentives: State Aid</th></tr>
<tr><td colspan="2">EUROPEAN CLUSTERS</td></tr>
<tr><td>Individual descriptions</td><td>Commonalities</td></tr>
<tr><td>Grenoble (Grenoble, France)</td><td rowspan="8">Type and volume<br>The analysed European clusters report to have benefited from State Aid in one form or another. The provided aid is mainly related to R&D support which corresponds to the general trend in Europe.<br><br>The role of State Aid<br>The role of State Aid for the analysed European clusters varies per cluster. State Aid proves to have played a significant role in Dresden and Grenoble. State Aid of more general nature was also used by DSP Valley and Eindhoven ASML, and Silicon South West. However, for the latter, State Aid was not of fundamental importance due to its low volumes.<br><br>Key barriers and challenges<br>• Focus on R&D and economically underdeveloped regions;<br>• Less attractive to build advanced manufacturing facilities in Europe;<br>• No differentiation between intra-European and global competition;<br>• High level of bureaucracy and lengthy timelines.</td></tr>
<tr><td>1.1.1 Type and volume<br>R&D-related State Aid<br>Support to major structural projects with large scale investments.<br>Examples of projects: Minalogic, Crolles 1, 2 and 3 Alliances, Minatec.<br>Total amount of State Aid: (2009): 398.7 million EUR; Crolles 3: 457 million EUR.<br><br>1.1.2 The role of State Aid<br>Consistent and long-term support for the cluster’s development.<br>Given that the cluster is of national and European importance, it is vital to involve national authorities in the investment efforts.<br><br>1.1.3 Key barriers and challenges<br>State Aid is mainly provided for R&D activities to further promote private investment in R&D and overall innovation.</td></tr>
<tr><td>Silicon Saxony (Dresden, Germany)</td></tr>
<tr><td>1.1.1 Type and volume<br>R&D-related State Aid<br>Support to R&D projects (for example, GLOBALFOUNDRIES, Infineon) - nowadays limited by the amended rules of the EU State Aid Action Plan in 2005. Public support to companies in the cluster - 80% of companies use public support.<br><br>1.1.2 The role of State Aid<br>80% of the companies in the cluster use public funding. Support to major structural investment concerning Fab 8 was critical to attract the major semiconductor manufacturer to the region.<br><br>1.1.3 Key barriers and challenges<br>State Aid for large scale investments is bound by State Aid regulation, which imposes a strong limitation on the maximum allowed State Aid intensity (66% reduction of State Aid intensity for investments > 100 million EUR, resulting in ~11% State Aid intensity for investments > 1000 million EUR).</td></tr>
<tr><td>DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)</td></tr>
<tr><td>1.1.1 Type and volume<br>R&D-related State Aid<br>Grants to small and medium sized microelectronics companies with the aim to try to help start-ups to pass through the difficult initial stages.<br><br>1.1.2 The role of State Aid<br>State Aid (for example, by IWT - Agency for Innovation by Science and Technology) was reported as the key external funding source for companies in the cluster, which are mostly SMEs.<br><br>1.1.3 Key barriers and challenges<br>In the Netherlands, due to recent changes in legislation, most subsidy programmes have been converted into tax exemptions. That means that companies first need to secure funding to finance business activities that generate costs or profits, to which these tax exemptions can be later applied.</td></tr>
<tr><td>Silicon South West (South West England, UK)</td></tr>
<tr><td>1.1.1 Type and volume<br>R&D-related State Aid<br>Grants to small and medium sized microelectronics companies with the aim to try to help start-ups to pass through the difficult initial stages.<br><br>1.1.2 The role of State Aid<br>State Aid funding helped many start-ups to overcome initial capital requirement problems.</td></tr>
</table>

| 1.1 Policy measures and incentives: State Aid | |
|---|---|
| SETsquared and iNets provide early-stage capital from which private sector funds can be leveraged.<br><br>**1.1.3 Key barriers and challenges**<br>State Aid only involves micro interventions. No structural State Aid in the form of e.g. test centres or manufacturing facilities. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)***<br>**1.1.1 Type and volume**<br>Federal money played a crucial role when it was most needed, i.e. from the 1940s to 1960s, but not nowadays. The only remaining chip production facilities are for prototype development work.<br><br>**1.1.2 The role of State Aid**<br>The active support of the federal government, particularly the US military and space programmes during the 1950s and 1960s, is reported to be critical to the rise of Silicon Valley.<br><br>**1.1.3 Key barriers and challenges**<br>The US does not have a system for the direct regulation of financial State Aid to firms. Recently, the US government has taken steps to limit the possible negative effects of such interventions by restricting the duration and depth of its intervention. | **Type and volume**<br>The two analysed clusters are located at different stages of the development cycle. This partially explains considerable differences in the type and volume of State Aid used.<br><br>**The role of State Aid**<br>In the case of both clusters, State Aid played a crucial role when it was most needed.<br><br>**Key barriers and challenges**<br>Although the State Aid process appears to be less regulated and controlled in the US, it is still reported to be highly bureaucratic, political and public, with lots of media attention surrounding the negotiations. |
| ***Tech Valley (Albany, US)***<br>**1.1.1 Type and volume**<br>R&D-related State Aid, Infrastructure-related State Aid<br>Large scale support for structural investments in education (specifically for nanoengineering), R&D and manufacturing.<br>*Examples of projects* (State Aid volume in brackets): GF Fab 8 (1.4 billion USD), G450C (approximately 150 million USD), SEMATECH North (160 million USD)<br><br>**1.1.2 The role of State Aid**<br>High levels of State Aid support were critical for the development of the cluster: i.e. to build the Nanotech Complex, attract SEMATECH, keep IBM, attract GLOBALFOUNDRIES and attract the G450C to the region.<br><br>**1.1.3 Key barriers and challenges**<br>The US does not have a system for the direct regulation of financial State Aid to firms. There is a threat that other clusters offer better benefit packages and that the companies will move away in the long run (for example, what occurred in Houston). | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)***<br>**1.1.1 Type and volume**<br>R&D-related State Aid<br>Extensive public support through the Five-Year-Plan for the industry. Current FYP (2011-2015) sets the goal to move from an output-based semiconductor industry (manufacturing) to a more R&D- and design-based semiconductor industry.<br><br>**1.1.2 The role of State Aid**<br>To develop a domestic high tech industry that fosters innovation and economic growth. Current FYP (2011-2015) emphasises the desire to develop a more R&D- and design-based semiconductor industry in China.<br><br>**1.1.3 Key barriers and challenges**<br>China has a very low share in semiconductor design, even though this cluster is particularly focused on design. There is also a key challenge in acquiring and creating IP, especially in design, and in | **Type and volume**<br>The type of State Aid we were able to detect in Asian clusters refers to R&D related support, and includes mainly grants to firms, loans and guarantees below market rates, and tax exemptions.<br><br>**The role of State Aid**<br>China's aggressive policies come from the desire to establish leading industries and, as a whole for China, to become a leading economic |

| 1.1 Policy measures and incentives: State Aid | |
|---|---|
| acquiring the latest technology. | force. |
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | **Key barriers and challenges**<br>Despite high levels of government support, China is still primarily a consumer, rather than a producer, of semiconductors. |
| **1.1.1 Type and volume**<br>R&D-related State Aid<br>Support for innovative start-ups through the National Development Fund (NDF) – often provides the full start-up capital. Also does not levy taxes on fuel and ensures lowest energy prices.<br>*Examples of projects*: TSMC, UMC.<br><br>**1.1.2 The role of State Aid**<br>State Aid through NDF made the start-up of companies like TSMC possible, which in particular pioneered the foundry model and became a major global force in semiconductor manufacturing.<br><br>**1.1.3 Key barriers and challenges**<br>The cluster emphasised the need to support newly emerging sectors instead of existing, strong, sectors (such as semiconductor manufacturing). | |

### *3.1.1.2. State Aid in Europe*

In general, State Aid is prohibited in Europe by the EC Treaty. Under some circumstances, however, government interventions are considered to be necessary for a well-functioning and equitable economy. Therefore, the Treaty leaves room for a number of policy objectives for which State Aid can be considered compatible. By complementing the fundamental rules through a series of legislative acts that provide for a number of exemptions, the European Commission has established a system of rules under which State Aid is monitored and assessed[50].

The control of State Aid has been established in 1958 as part of the European Treaty in order to avoid trade disputes between Member States. In its beginning, State Aid control played a minor role and was implemented inconsistently. Considerable changes in the way the issue of State Aid was treated began with a shift towards a single European market in the mid-1980s. In 2005, the reorientation of EU State Aid policy by the State Aid Action Plan[51] was launched. The aim of the new approach was “less and better targeted” State Aid, i.e. regional and sectoral aid should be reduced and the maximum aid intensity (incentive as a percentage of the investment) for investment should be lowered significantly[52].

#### *Type and volume*

Despite some complications related to State Aid use in Europe (which we will elaborate on below), all of the analysed European clusters report to have benefited from State Aid in one form or another. The provided aid is mainly related to R&D support which corresponds to the general trend in Europe.

In the case of Grenoble, local authorities, specifically the Rhone-Alpes region and the Isere General Council, are reported to have provided consistent and long-term support to the cluster’s

[50] http://ec.europa.eu/competition/state_aid/overview/index_en.html
[51] “State Aid Action Plan. Less and better targeted state aid: a roadmap for state aid reform 2005 - 2009”, COM(2005) 107 final, available at http://ec.europa.eu/competition/state_aid/reform/saap_en.pdf
[52] Adapted from Wydra S. (2011) “Innovation and industrial policy for Key Enabling Technologies in Europe – findings for micro/nanoelectronics and industrial biotechnology”, paper presented at the 3rd European Conference on Corporate R&D and Innovation CONCORD-2011, October 6th 2011, Seville (Spain); available at http://iri.jrc.ec.europa.eu/concord-2011/papers/Wydra_Sven.pdf

development in order to stimulate local economic development. This support includes financial aid for R&D projects and investment in the cluster's major structural projects (Crolles 1, Minatec, Crolles 2, Minalogic and Crolles 3)[53]. Although France has differentiated support schemes, State Aid has recently been reduced there. This is due to changes in the European State Aid control in the last decade, which limits the ceilings of the maximum aided significantly below the largest State Aid amounts provided in other countries[54].

The ceilings for State Aid intensity refer to the maximum quota of eligible costs of a project to which State Aid is allowed. These ceilings have been significantly reduced in the last decade, in particular for large scale investments. Overall, the mechanisms of compatibility assessments and ceilings for State Aid intensity differ between various kinds of policy instruments, i.e., horizontal measures (for example, R&D funding[55] and SME promotion) and sector-specific measures such as investment aid (for example, Regional Aid)[56]. In the box below, we present an example of a reduction made in State Aid intensity in Silicon Saxony (Dresden, Germany). The example shows how effective State Aid intensity can be lowered on amounts higher than 50 million EUR.

**Example of reduction in State Aid intensity**

Consider a 1 billion EUR investment that creates 1,000 WP. According to the incentive intensity rules, a maximum of 30% of the investment can be provided in State Aid. Hence:

30% x 1 billion EUR = 300 million EUR

However, as the funding for the project is vastly more than 50 million, the reductions need to be applied. The maximum amount of State Aid that can be provided can be described as following:

FQ = R*(50 + 0.5B + 0.34C)

Where FQ is the maximum funding quota, R* is the existing maximum incentive intensity, 50 (million EUR) the amount that can be granted with the maximum incentive intensity, B the amount between 50 to 100 million EUR and C the amount above 100 million EUR.

The total amount of State Aid that can thus be provided on the 1 billion investment is:

0.3*(50+0.5*50+0.34*900) = 114.30 million EUR

The State Aid intensity thus equals 114.30 million EUR / 1 billion EUR = 11.43%

While the example above implies that maximum funding quota is calculated on the basis of direct cash incentives only, it is important to consider the following. According to Article 87 of the EC

[53] OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development

[54] http://www.tab-beim-bundestag.de/de/pdf/publikationen/berichte/TAB-Arbeitsbericht-ab137.pdf

[55] The new framework has introduced differentiated thresholds of 20 million EUR for projects that are predominantly for fundamental research, 10 million EUR for projects that are predominantly for industrial research and 7.5 million EUR for projects that are predominantly for experimental development. Such differentiated ceilings aim to reflect the underlying risks of distortions of competition. These risks depend primarily on the amount of aid a Member State wants to grant, but also on the question how far the research project is away from the market.
See http://europa.eu/rapid/press-release_MEMO-06-441_en.htm

[56] Adapted from Wydra S. (2011) "Innovation and industrial policy for Key Enabling Technologies in Europe – findings for micro/nanoelectronics and industrial biotechnology", paper presented at the 3rd European Conference on Corporate R&D and Innovation CONCORD-2011, October 6th 2011, Seville (Spain); available at http://iri.jrc.ec.europa.eu/concord-2011/papers/Wydra_Sven.pdf

Treaty, *"any aid granted by a Member State or through state resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the common market*"[57]. In practice, this means that the European Commission takes into account various State Aid instruments that are directly related to the same eligible costs. These instruments include grants and tax exemptions, equity participation, soft loans and tax deferrals, and guarantees[58]. This is also evidenced by the GLOBALFOUNDRIES and Qimonda cases, where various State Aid instruments were considered in the formal authorisation process.

The German government offers various alternatives of State Aid with the motivation to support innovative enterprises located in Silicon Saxony. The members of the Silicon Saxony cluster can profit from favourable investment conditions, support in R&D, and support in employment and qualification. The investment incentives include loan programmes, equity capital assistance, and financial and cash-value incentives (Investment Allowance and Investment Grants). Until 2013, the whole of Saxony (apart from the region Leipzig which is being phased out) is among the areas in Germany which enjoy the highest priority for incentives. This translates into the highest incentive intensity in Germany of 30%[59] being attributed to Saxony. At the same time, as illustrated by the box above, special rules are applied to higher amounts of State Aid funding.

In the case of DSP Valley and Eindhoven ASML (the Netherlands and Belgium), both the Dutch and Belgian governments contribute financially to the cluster's development. It is worth noting however that the State Aid provided here is not specifically focused on the semiconductor industry, and is rather of a general nature. For example, the Flemish VIS-programme provides subsidies for four types of innovation activities: collective research, technical advice, thematic innovation stimulation, and sub-regional innovation stimulation. The Dutch government allocated in total hundreds of millions EUR to the improvement of infrastructure around the Eindhoven region. Several examples of this were found. In 2008, the Ministry of Economic Affairs of the Netherlands reserved a budget of 27 million EUR for the Eindhoven region (Southeast Netherlands), called the "Nota Ruimte". The "Nota Ruimte" provided Brainport Avenue, the Eindhoven part of the cluster, with 75 million EUR in funding. Moreover, The Ministry of Traffic and Infrastructure has allocated 254 million EUR to the improvement of infrastructure around the Eindhoven region[60]. At the European level, the Interreg 3 funding, in particular through the Interreg Vlaanderen-Nederland and Interreg Euregio Maas-Rijn, has played a crucial role in developing the cluster from Leuven across the border towards Eindhoven and Aachen. Despite the rather general nature of State Aid funding in the cluster, it was reported to be a key external funding source for companies, which are mostly SMEs.

Finally, in the case of Silicon South West (UK), State Aid only involves small levels of micro interventions. It is hard to draw the correlation between these micro interventions and the establishment of big players in the region. The UK has never had structural State Aid in the form of a microelectronics test centre or a doctoral training centre for microelectronics. These micro interventions do, however, create an ecosystem, which allows for an innovation centre to emerge where entrepreneurs can meet and ideas can be developed. It also serves to contribute to the

[57] http://europa.eu/legislation_summaries/taxation/l31047_en.htm
[58] http://ec.europa.eu/competition/state_aid/studies_reports/conceptual_remarks.html#categ_aid
[59] http://www.invest-in-saxony.net/set/157/2012-02-09%20IncentSaxony_EN.pdf
[60] "Spatial Programme Brainport, Eindhoven region", Samenwerkingsverband Regio Eindhoven (SRE), November 2009, available at: http://urbact.eu/fileadmin/Projects/Joining_Forces/documents_media/LAP_EINDHOVEN_English.pdf

reputation of the region, which in turn attracts more entrepreneurs. These interventions, however, have never been significant and therefore historically it has been venture capital that has stimulated the market and played a significantly more important role in the cluster.

***The role of State Aid***

The role of State Aid for the analysed European clusters ***varies per cluster***. State Aid has played a significant role in Dresden and Grenoble, enabling these clusters to develop as the semiconductor hotspots in Europe by luring substantial investments to these regions and therefore fuelling the growth of the semiconductor industry in the area. As highlighted above, State Aid of a more general nature has also benefited DSP Valley and Eindhoven ASML. For Silicon South West, however, State Aid was not of fundamental importance due to its low volumes.

***Key barriers and challenges***

The key identified barriers and challenges related to State Aid in Europe can be summarised as follows:

- In Europe, State Aid is ***focused on R&D and on economically underdeveloped regions***. The latter opposes the needs of high-tech clusters (such as semiconductor clusters) which require large infrastructural investments.
- Current State Aid regulation ***makes it less attractive for companies to build state-of-the-art leading-edge manufacturing facilities in Europe***. Apart from the strong dilution of investments worth over 50 million EUR, there are two other aspects contributing to this factor: (1) not all regions in the EU can apply for regional aid; and (2) large companies that have a market share of more than 25% are not eligible for investment aid.
- Lack of semiconductor motivation to take root in Europe, in turn, means a decrease in large scale semiconductor investments and the missing out on the accompanying long-term employment and benefits to the innovation ecosystem.
- The current European State Aid rules ***do not differentiate between intra-European and global industry sectors***. The rules are focused on the proper functioning of the European internal market, while for the semiconductor industry, it is suggested that intra-European competition no longer exists (for example, between countries such as France, Germany, UK, Netherlands as analysed in this study). Instead, the competition is now between Europe and the rest of the world, with other regions around the world implementing a wide set of measures to attract investments.
- The current State Aid regime is reported to be associated with ***high levels of bureaucracy and lengthy timelines***, while similar processes in Asian countries are reported to be much quicker.

#### ***3.1.1.3. State Aid in the United States***

State Aid in the US is managed at the state level, instead of the federal level. US states may provide certain assistance to firms, but under the "*dormant Commerce Clause*" of the US Constitution, their actions must not discriminate against other states or hinder interstate commerce. The Commerce Clause prohibits economic protectionism, i.e., regulatory measures designed to benefit in-state economic interests by burdening out-of-state competition. At the same time, states and local authorities regularly provide tax breaks and other incentives to attract new investors[61].

Courts have found that certain state assistance violates the Commerce Clause of the US Constitution. There is a particular aspect of the Commerce Clause that implicitly limits the states' right to tax or otherwise regulate interstate commerce. In general, a challenged credit or exemption will not survive the Commerce Clause if it provides a direct commercial advantage to local business. In relation to the Commerce Clause, discrimination refers to the different treatment of in-state and out-of-state economic interests which benefits the former and burdens the latter. A state tax that discriminates against interstate commerce is therefore considered invalid unless it serves a "legitimate local purpose" that cannot be adequately served by non-discriminatory alternatives[62].

***Type and volume***

The two analysed clusters are located at different stages of their development cycle with regard to the semiconductor industry, with Silicon Valley (California) being a much older cluster currently going through its decline phase (with regard to the semiconductor industry) while Tech Valley (New York) is at its rise. This partially explains the considerable differences in the type and volume of State Aid used.

The active support of the federal government for the semiconductor industry, particularly the US military and space programmes, is reported to have been critical to the rise of Silicon Valley. However, no recent infrastructure-related State Aid support for the semiconductor industry was detected in the cluster.

For the Tech Valley cluster, various types of State Aid are available to companies or institutions. These include direct funding, provision of infrastructure, support of educational and research facilities, and cheap power. The goal of the State Aid initiatives in New York is to *"create a powerhouse of intellectual assets and cutting edge infrastructure to provide the nanotechnology industry with key enabling innovations"*[63]. The philosophy behind this powerhouse of high-tech industry is the provision of the jobs of the future and the fostering of economic growth. In this case, both R&D and infrastructure-related State Aid are available to the cluster.

***The role of State Aid***

In the case of Silicon Valley, federal money played a crucial role when it was most needed, which was during the period when the foundation for that growth was being built and key aspects of the Silicon Valley business culture were being developed and refined, i.e., from the 1940s to the 1960s. The

[61] "Competition, State Aids and Subsidies: Contribution from the US Federal Trade Commission", OECD, February 2010, paper presented at Global Forum on Competition on 18 and 19 February 2010, available at http://www.ftc.gov/bc/international/docs/stateaidftc.pdf

[62] "Competition, State Aids and Subsidies: Contribution from the US Federal Trade Commission", OECD, February 2010, paper presented at Global Forum on Competition on 18 and 19 February 2010, available at http://www.ftc.gov/bc/international/docs/stateaidftc.pdf

[63] "New York's Nano Initiative", presented by Dr. Pradeep Haldar at Growing Innovation Clusters for American Prosperity, 2009. Available at http://sites.nationalacademies.org/PGA/step/PGA_051223.

impact of State Aid was considerably smaller during the valley's years of growth in the late 1970s and the 1980s. State Aid is reported to be less critical nowadays.

In the case of Tech Valley, State Aid made a number of developments, such as the NanoTech Complex, possible. Moreover, the offered tax breaks and direct funding ensured a competitive bid for attracting GLOBALFOUNDRIES' multibillion USD manufacturing facility. In turn, the existence of the NanoTech Complex was key in GLOBALFOUNDRIES' decision to settle in Tech Valley. Furthermore, the combined presence of the NanoTech Complex, GLOBALFOUNDRIES and SEMATECH, as well as considerable State Aid investment, served to attract the Global 450mm Consortium, which is committed to develop the next generation wafer fabrication technology, to the region. It was suggested that if it had not been for the State Aid, Tech Valley would hardly have gotten off the ground. ***State Aid, however, should be considered as one among other crucial success factors for the cluster rather than the only one***.

***Key barriers and challenges***

The US does not have a system which directly regulates the financial State Aid provided to firms. In some special instances, the US Government has provided assistance to industries and firms to address specific challenges, for example, to protect critical infrastructure, employment and national defence, and maintain the integrity of the banking and financial system. Recently, the US Government has taken steps to limit the possible negative effects of such interventions by restricting the duration and depth of its intervention[64].

Although the State Aid process appears to be less regulated and controlled in the US, it is still reported to be highly bureaucratic, political and public, with lots of media attention surrounding the negotiations. It was suggested, however, that despite these factors, constructive solutions which are beneficial for the industry and allow developing it further can be found[65].

#### *3.1.1.4. State Aid in Asia*

State Aid measures are reported to be popular in Asia. It was suggested that Taiwan or China would have been unable to build their competitive foundries if they did not have public support that was higher than the combined public support granted in Europe and US over the same time period.

The semiconductor business provides a high percentage of direct and indirect jobs in some Asian countries. Various Asian governments thus try to keep these key sectors present in their respective economies. For manufacturing, in particular of Dynamic Random Access Memory (DRAM) chips, these subsidies counteract the reduction of worldwide capacities which was brought about by market mechanisms through price erosion and lower global demand[66]. State Aid is therefore needed to keep these manufacturers in business.

***Type and volume***

[64] "Competition, State Aids and Subsidies: Contribution from the US Federal Trade Commission", OECD, February 2010, paper presented at Global Forum on Competition on 18 and 19 February 2010, available at http://www.ftc.gov/bc/international/docs/stateaidftc.pdf

[65] See also https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/1._Framework_Conditions_report_Final.doc.pdf

[66] PwC (2009) "Semiconductors: A change of pace for the semiconductor industry?"

The type of State Aid we were able to detect in Asian clusters refers to R&D-related support, and includes mainly grants to firms, loans and guarantees below market rates, and tax exemptions. Moreover, many companies in these clusters start off as (partially) state-owned enterprises (SOEs). In many cases, the state continues to hold shares in the company, either directly or through, for example, a state-owned (development) fund.

With respect to the semiconductor industry, China's current Five-Year Plan (2011-2015) specifically targets the expansion of China's microelectronics supply chain. This expansion aims to meet the needs of regional and global markets. Billions of USD will be invested to fuel the growth of the Chinese semiconductor industry during this period[67]. The Five-Year-Plan sets out six measures to stimulate the development of China's software and semiconductor industries, with semiconductor firms meeting certain conditions being eligible to receive state funding support. In addition, the government will introduce new tax breaks and incentives to encourage independent innovation[68].

The companies accommodated in the Hsinchu Science Park (Taiwan) can benefit from State Aid options such as: grants to firms for investment, R&D, employee training; loans and guarantees below market rates; discretionary deferral of or exemption from tax, social security and other payments to the state; and sale or lease of public land or property at discounted rates[69].

***The role of State Aid***

China is widely known for its generous State Aid conditions. Its aggressive policies come from the desire to establish leading industries and, as a whole for China, to become a leading economic force. This desire is also evidenced by the aggressive goals set in their five year plans[70]. State Aid is a means of ensuring that these goals are met and that globally leading industries are established in China. Moreover, stimulating leading companies to set up facilities in China not only fosters economic development, but also affects technology transfer. These companies often need incentives, which can be found in a variety of policies which include subsidies, grants and preferential loans.

In the case of Hsinchu Science Park in Taiwan, State Aid has been an essential factor contributing to the establishment of the cluster itself. The government has implemented favourable conditions in order to attract firms, human capital and investments into the Hsinchu area, which has led to the Taiwanese semiconductor industry becoming one of the key clusters in the world. Only two decades after the emergence of the first few semiconductor businesses in the early 1980s, the Taiwanese semiconductor industry was ranked the fourth largest in the world and consisted of nearly 400 companies. All of the profitable conditions offered by the Taiwanese government were part of a strategy of letting firms specialise and enabling them to be quick to go from design to production. As for the direct financial support for the construction of new facilities, not much information is being disclosed.

It is important to note that the Taiwanese innovation system and related policies are based on the relatively high importance of SMEs in the country. Large private companies are more the exception

[67] http://www.electroiq.com/articles/sst/2012/02/semicon-china-challenges-and-opportunities-for-semiconductor-emerging-markets.html
[68] PwC (2011) "Continued growth: China's impact on the semiconductor industry, update 2011".
[69] Chew et al. (2007): "Taiwan: Semiconductor Cluster", Harvard Business School, Massachusetts, US
[70] http://sectors.investottawa.ca/key-sectors/china

than the rule, and in that sense Taiwan is significantly different from other Asian Countries such as Japan and China. Most large companies in Taiwan are in fact state corporations[71].

***Key barriers and challenges***

Despite high levels of government support, China currently only has a strong share in the assembly- and test and back-end-manufacturing segments. China is primarily a consumer, rather than a producer, of semiconductors. The influence Chinese companies have in the design, and other elements, of global semiconductor chips is estimated to be just 1% to 2% of finished chips. Despite domestic consumption being roughly 33% of the global semiconductor market, it has also been noted that Chinese semiconductor design and selection in major companies claim less than 4% of global revenue in semiconductor design and front-end manufacturing[72].

The key reasons for this state of affairs among others refer to the fact that export of IP is often banned by the IP's home countries such as the US, which leaves China behind as most of the IP in the semiconductor industry is owned by foreign players[73]. Nevertheless, the development of the industry is a key government priority.

As for Taiwan, government support continues to play a particularly important role in the Taiwanese semiconductor innovation system. However, over time, the importance of state-owned enterprises is beginning to shrink. The key priority for the government at the moment is to support knowledge generation, transfer and application in order to stay ahead of China (which is viewed as a key competitor due to cheaper labour and a promising domestic market) and gain international technological competitiveness in new application fields[74].

#### ***3.1.1.5. Lessons for Europe***

Governments of several Asian countries and specific states like New York demonstrate their clear commitment to the development of the semiconductor clusters in their respective regions. Various State Aid measures are employed for this purpose such as grants to firms for investment, R&D, employee training; loans and guarantees below market rates; discretionary deferral of or exemption from tax, social security and other payments to the state; and the sale or lease of public land or property at discounted rates. Such measures (which to a large extent are not related to direct funding for production facilities) create favourable benefit packages that serve to attract companies from all over the world.

At the same time, it has been suggested that Europe is thinking more from the perspective of a liberal economy and expecting the industry to be driven mainly by the private sector. The rules and regulations applicable to State Aid in Europe are reported to be too strict and imply complicated bureaucratic procedures (in contrast with Asia and to some extent the US). Additionally, in Europe,

[71] See also Wydra et. al. (2010) "Wettbewerbsfähigkeit der europäischen Wirtschaft im Hinblick auf die EU-Beihilfepolitik – am Beispiel der Nanoelektronik", Innovationsreport, *TAB-Arbeitsbericht Nr. 137. Berlin 2010, 228 Seiten*
[72] McKinsey&Company (2011) "The challenge of China", available at http://www.mckinsey.com/Client_Service/Semiconductors/Latest_thinking/The_challenge_of_China
[73] McKinsey&Company (2011) "The challenge of China", available at http://www.mckinsey.com/Client_Service/Semiconductors/Latest_thinking/The_challenge_of_China
[74] See also Wydra et. al. (2010) "Wettbewerbsfähigkeit der europäischen Wirtschaft im Hinblick auf die EU-Beihilfepolitik – am Beispiel der Nanoelektronik", Innovationsreport, *TAB-Arbeitsbericht Nr. 137. Berlin 2010, 228 Seiten*

governmental support to the semiconductor industry is mainly provided in the form of R&D programmes. Examples from other regions around the world illustrate that one can consider ***introducing additional benefits for companies*** (see Asian model) or ***softening the rules for regional State Aid*** (for example, removing the ceiling for State Aid intensity; extending the scope of State Aid and including product development-related activities). Both approaches are suggested as being crucial for manufacturing in Europe to be competitive. We will elaborate on these suggestions in Chapter 4 of this report.

## *3.1.2. Tax incentives*

Chapter 2 introduced the definition of tax incentives. Aside from tax exemptions, there are multiple other tax incentives available. For example, R&D tax credits (RTCs) are introduced to promote research and innovation in which the industry takes an active part. Similar to other tax incentives, a company must have taxable profits in order for the support to have any value. Other tax incentives can be found in, for example, reduced corporate tax rates, tax deferrals or tax holidays. Below we elaborate on the key findings with regard to this policy measure.

### *3.1.2.1. The importance of tax incentives for the development of the semiconductor clusters*

Tax incentives were suggested to have a significant impact on the semiconductor industry. According to the Organisation for Economic Co-operation and Development (OECD), R&D is seen as a crucial investment target for the growth of economies in the long run[75]. Governmental support in the form of tax incentives may substantially help to maintain jobs, especially in times of crisis, and contribute to national competitiveness. Generous incentives through R&D tax incentives can make a country a relatively more attractive location for R&D investments than other nations. Furthermore, R&D investments are risky, which means that firms, especially small firms and start-ups, are more likely to be credit-constrained when investing in R&D. Therefore, tax incentives may have a beneficial outcome for these entrepreneurial units in particular. Last but not least, R&D tax incentives contribute to knowledge spillovers to other firms and organisations, making the industry as a whole more competitive[76].

For the European and US clusters, the most relevant tax incentive refers to R&D tax credits. The R&D tax credit is viewed as an effective tool for boosting innovation, competitiveness and creating high-wage employment, by[77]:

- Creating an incentive for public-private partnerships to fuel innovation and economic activity;
- Spurring innovation and start-up companies;
- Seeding surrounding areas with additional investment in not only scientific research but also indirect business benefits;
- Anchoring high-tech business investments near research facilities; *and*
- Enabling rapid time-to-market production when manufacturing plants are located close to research.

[75] "R&D tax incentives: rationale, design, evaluation" OECD, November 2010, retrieved from http://www.oecd.org/dataoecd/61/13/46352862.pdf
[76] "R&D tax incentives: rationale, design, evaluation" OECD, November 2010, available at http://www.oecd.org/dataoecd/61/13/46352862.pdf
[77] http://www.sia-online.org/public-policy/tax/

In the Asian clusters, we also observed a strong use of tax deductions, tax deferrals or tax holidays. These tax incentives specifically aim to increase the attractiveness of the region by offering clear benefits for newly established companies, or, in some cases, existing companies in the region. Tax holidays of this sort, however, are not allowed in Europe[78].

Table 3-2 presents an overview of the key findings on the tax incentives in the analysed clusters.

TABLE 3-2: Overview of key findings on policy measures and incentives: Tax incentives

| 1.2 Policy measures and incentives: Tax incentives | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | Most tax incentives in the European clusters are **explicitly linked to R&D activities**. With the exception of Germany, **R&D tax credits** comprise a key instrument. Other instruments include **tax exemptions for innovation-intense companies** ("Innovation Box", "Patent Box" or tax deductions on gross patent income) or for young innovators (JEI). |
| ***Research tax credit (crédit impôt recherche – CIR)***<br>The general corporate tax rate in France is 34.43%. France is suggested to have the best research tax credit in Europe. It is a corporate tax relief measure based on R&D expenses incurred by firms operating in France. If the companies are eligible to make use of CIR for the first time, the applicable rate is 50% the first year, and 40% the second year. Later it equals 30% of R&D expenditures up to 100 million EUR; after reaching this threshold, the rate comes down to 5%. Other public support for R&D (subsidies, refundable loans etc.) must be deducted from the base in order to calculate the credit.<br>The research tax credit is a general measure, which does not target any industry specifically, but only supports corporate R&D activities in general.<br><br>***Tax relief for Young Innovative Enterprises ( "Jeune Entreprises Innovantes" - JEI)***<br>The firms that can benefit from JEI are SMEs which are less than 8 years old, but only as long as they meet the following five criteria: it must be (1) an SME as defined by the EU, (2) young, (3) independent, (4) genuinely new, and (5) with R&D costs comprising at least 15% of its expenses. Being attributed as a JEI implies full tax exemption for the first 3 profitable fiscal years followed by 50% relief for the next two profitable years, full exemption from the Annual Minimum Tax and seven years' exemption from local business tax and/or property tax. The company also gets an exemption for employers' contributions for employees involved in research activities, for a maximum of eight years. | |
| ***Silicon Saxony (Dresden, Germany)*** | |
| There are no tax advantages provided in Germany as a whole, including Silicon Saxony. The public authorities provide benefits in other forms. One of the key reasons for the government not providing tax incentives is to prevent abuse of credits. The German government prefers to support individual projects in other ways, such as through direct funding. | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| The tax benefits of the cluster differ according to geographical area, as different Member States – Flanders and the Netherlands - are involved. The tax incentives that are in place are not particular to the semiconductor industry and are nationwide. These include R&D tax credits, indirect tax incentives (VAT grouping), corporate tax exemption for R&D income derived from self-developed patented intangible assets ("Innovation Box"), and patent deductions, which allows companies located in Belgium to deduct 80% of their gross patent income from their tax base. The Netherlands offer a comparatively low corporate tax rate of 20% (up till 200,000 EUR) to 25%. Companies in Flanders face corporate taxes of 34%[79]. | |
| ***Silicon South West (South West England, UK)*** | |
| Existing tax reliefs are nationwide and do not apply particularly to the cluster or the semiconductor industry. These tax reliefs are mainly aimed at attracting foreign | |

[78] https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/1._Framework_Conditions_report_Final.doc.pdf
[79] http://taxfoundation.org/article/countdown-over-were-1

| 1.2 Policy measures and incentives: Tax incentives | |
|---|---|
| multinationals to the country.<br>They include relatively low personal income tax and corporate tax rates, specific tax reliefs aimed at innovation, e.g. tax deductions and cash refund options on R&D expenditure, and available tax reliefs for companies investing in intangibles. There are also tax incentives specifically aimed at entrepreneurs such as the Enterprise Investment Scheme, which aims to help smaller high-risk trading companies raise finance, and reliefs of capital gains tax for entrepreneurs. The proposed introduction of the "patent box in 2013/2014" is a further attempt to use targeted tax exemptions to encourage innovation-intensive companies. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | Tax policy in the US clusters is dominated by federal ruling. Although state taxes are applied, the federal tax rate dominates the corporate tax level. Moreover, R&D tax credits are instated at the federal level, but have lapsed as of 1 January 2012. |
| The federal R&D tax credit 0f 20% was temporary in nature and expired in January 2012. The California R&D tax credit (currently 15%) implies that taxpayers can reduce tax liability to the extent that they conduct qualified R&D activities within California. California's reputation as the "Golden State" has lost much of its flair over the past few years as a result of ongoing fiscal challenges and growing tax burdens.<br>US has one of the world's highest corporate tax rates (39.2% when both federal and state rates are included). | |
| ***Tech Valley (Albany, US)*** | |
| In Tech Valley several tax incentives are available. Most of these, however, are negotiated as a one-off deal. The state of New York has for instance provided tax breaks to lure initial investments to the area. One key tax incentive was the federal R&D tax credit, equal to 20%. Companies are eligible to apply for R&D tax credits if they offer employment for (high-tech) R&D activities. The R&D tax credit has, however, lapsed as of 1 January 2012. Congress can reinstate it retroactively, as it has done nine times previously[80]. Furthermore, the US has the world's highest corporate tax rate (39.2% when both federal and state rates are included). | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)*** | The Asian clusters showcase a number of aggressive tax incentives, including the use of R&D tax credits, tax holidays and tax deferrals. Moreover, companies in the clusters can benefit either from low national corporate tax rates, or from significantly reduced corporate tax rates. |
| Officially, the corporate tax rate in China is 25%. In the cluster, however, many tax incentives are in place. The main channels of tax incentives are R&D tax credits, tax holidays and tax deferrals. While many tax incentives hold for different industries, some specifically apply to semiconductor companies. These measures include:<br>• Newly established chip design companies enjoy a two-year tax exemption and a 50% tax reduction in the subsequent 3 years;<br>• Key companies listed in the State's plan that do not benefit from this, enjoy a reduced tax rate of 10%;<br>• In addition, the depreciation period of the equipment may be shortened to three years (with approval of the tax authorities); *and*<br>• Chip producing companies below a certain size may be eligible for further tax exemptions. | |
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | |
| Taiwan has one of the lowest corporate income tax rates in the world (reduced from 20% to 17% in 2010). On top of that, companies in HSP are entitled to a five-year tax holiday. Certain companies are also exempt from import duties, commodity tax and business tax. When exported, all HSP-produced products and labour outputs are exempted from business taxation.<br><br>These taxation incentives aim to increase the attractiveness of HSP to high-tech investment and help the capital accumulation of high-tech firms in HSP. They also served to help companies located in HSP experience tremendous recovery in the light of | |

[80] Tyson, L. and G. Linden (2012). "The Corporate R&D Tax Credit and US Innovation and Competitiveness: Gauging the Economic and Fiscal Effectiveness of the Credit", Center for American Progress.

| 1.2 Policy measures and incentives: Tax incentives | |
|---|---|
| the global financial crisis in 2009, as well as spur the development of a number of emerging industries. | |

#### *3.1.2.2. Tax incentives in Europe*

In Europe, various tax incentives are offered across the analysed clusters. Most of these tax incentives explicitly target R&D-related activities. Furthermore, within Europe, large differences in corporate tax rates can be observed. While the Netherlands offers a relatively low corporate tax rate of 20% to 25%, the Belgian and French fiscal authorities tax 34% and 34.43% on corporate income respectively.

Many European countries offer tax relief for R&D activities in the form of R&D tax credits[81]. France is suggested to offer one of the most generous research tax incentives in the world. The current tax incentive system is particularly favourable for SMEs. At the same time, corporate tax in France is high (it is the third highest corporate tax in the world after the US and Japan). Although it may be an issue for the whole industry in France, it is reported to be of lower importance for the semiconductor industry. The latter is a capital-intensive industry in which cost of labour is suggested to be a less important point. At the same time, Germany has lower corporate tax rate but no R&D credit. Hence, higher corporate tax in France is partly compensated by an attractive R&D tax credit scheme, which results in a so-called *selective balance* in the tax system. In the Netherlands, however, a relatively low corporate tax rate is also coupled with R&D tax credits.

Tax incentives in Europe have become a key element of public policy in favour of research and innovation. In France, the research tax credit represents a vital element of an innovative company's financial plan, and is well adapted to the needs of SMEs. This tax incentive enables companies to increase their competitiveness by supporting their R&D efforts[82].

Aside from R&D tax credits, other tax incentives are offered in Europe. A number of tax incentives imply corporate tax exemptions on activities that relate to innovation. Such incentives have also been referred to as "innovation-friendly tax incentives"[83]. These incentives include partial corporate tax exemptions for innovation-intense companies ("Innovation Box" in the Netherlands, "Patent Box" in the UK), tax deductions on gross patent income, and tax deferrals and exemptions for young innovators ("Jeune Entreprises Innovantes", France).

All in all, Europe offers a rather comprehensive set of tax incentives. These tax incentives are almost exclusively related to R&D activities. Moreover, some regions offset relatively high corporate tax rates with strong R&D-related tax incentives (for example, France), or vice versa (for example, Germany), resulting in a selective balance in the tax system. There are, however, exceptions to this, such as the Netherlands which offers both a relatively lower corporate tax rate as well as various R&D-related tax incentives.

[81] European countries that offer R&D tax credits are Austria, Belgium, France, Ireland, Italy, Portugal, Spain and the United Kingdom. However, this specifically concerns R&D tax credits. Other European countries like Czech Republic, Netherlands, and Poland offer other forms of R&D tax incentives, e.g. by allowing for specific tax deductions. Source: internal PwC Tax database per country

[82] French government document available at http://www.diplomatie.gouv.fr/en/IMG/pdf/ArguCIR_nov08_UK.pdf

[83] https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/1._Framework_Conditions_report_Final.doc.pdf

***Key barriers and challenges***

Europe in general offers strong tax incentives for R&D related activities. However, some concerns have been raised regarding the competitiveness of European tax policy at the global level, particularly with respect to Asia. As described below, Asian countries offer aggressive tax incentives, including tax holidays that are not allowed in Europe[84]. In response, some European countries and regions are experimenting with innovation-friendly tax incentives. This subsequently leads to the risk that companies move their operations to regions that offer these aggressive tax incentives.

A second key challenge in Europe relates to the lack of tax incentives in Germany. Experts argue that the introduction of tax incentives for R&D is long overdue[85]. This is not disputed and is part of the German government's coalition agreement for the present legislative period, where it is argued that there are insufficient R&D incentives for companies in Germany.

To have a competitive tax regime in place, the following three policies need to be implemented in Germany as a whole[86]:

- Introduce tax incentives for R&D support budget consolidation;
- Grant a 10% tax credit; *and*
- Provide tax incentives for research-based companies of all sizes.

As long as the federal government does not act on these challenges, Silicon Saxony may be at a comparative disadvantage regarding the tax regime.

### *3.1.2.3. Tax incentives in the United States*

Companies based in the US operate at a disadvantage under the current US tax policy which implies high corporate tax rates, a worldwide tax system and no permanent R&D credit. At the same time, other countries in Europe and Asia offer a combination of generous credits, grants, and reduced tax rates to invest and build semiconductor operations there[87].

The main tax incentive that was available in the US was the R&D tax credit. Companies are eligible to apply for R&D tax credits if they offer employment for (high-tech) R&D activities. The federal R&D tax credit has, however, lapsed as of 1 January 2012. Congress can reinstate it retroactively, as it has done nine times previously[88], but momentarily it is a key point of concern for the US clusters.

The state of California, where Silicon Valley is located, offers a permanent R&D tax credit itself. Despite that, growing numbers of R&D activities are heading to other states and countries to start new businesses or to expand R&D labs. In a survey of California-based high-tech firms, researchers

[84] https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/1._Framework_Conditions_report_Final.doc.pdf
[85] "Roadmap to a Resource Efficient Europe", VCI, 2012
[86] "Roadmap to a Resource Efficient Europe", VCI, 2012
[87] SIA Tax Reform position paper available at http://www.sia-online.org/clientuploads/directory/DocumentSIA/Tax%20Reform/Tax%20Reform_Position_v8.pdf
[88] Tyson, L. and G. Linden (2012). "The Corporate R&D Tax Credit and US Innovation and Competitiveness: Gauging the Economic and Fiscal Effectiveness of the Credit", Center for American Progress.

from the University of California at Berkeley found that along with manufacturing, R&D is one of the first functions to be outsourced to other states or foreign countries[89].

Another key concern in the US is the high corporate tax rate combined with a lack of tax benefits compared to other countries. Figure 3-1 shows the cost differences between building semiconductor factories in the US and in other countries. Lower labour costs and capital grants comprise only part of the cost differences; the main difference in costs can be attributed to the differences in tax benefits. To counter this, the State of New York has made an effort to provide a competitive benefit package for the semiconductor industry. GLOBALFOUNDRIES revealed that the benefit package offered by the State of New York matched offers made by China, Brazil and Russia[90]. The specifics of the tax incentives, however, are not publically available, although most experts point to them comprising approximately 650 million USD in cash with the remainder in the form of tax benefits[91].

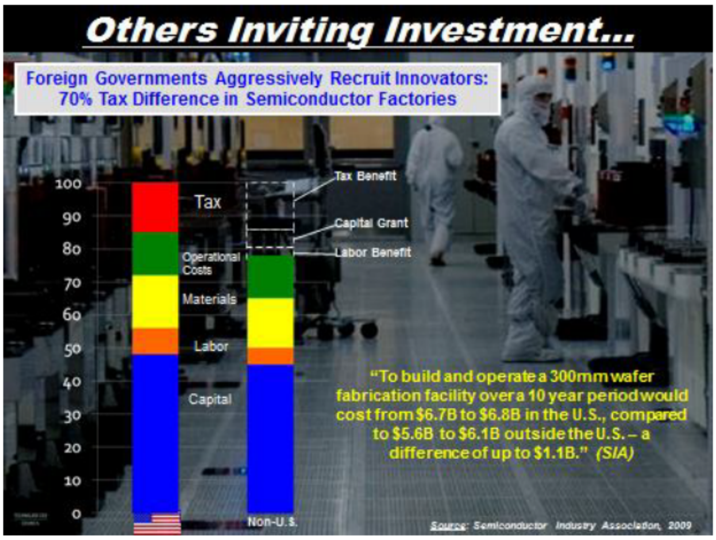


FIGURE 3-1: Tax difference in semiconductor factories between the US and other countries (Source: Semiconductor Industry Association, 2009)

A final point to take in consideration is the fact that the US has a *worldwide tax system* in place. This means that companies in the US are taxed in the US for global activities. The main disadvantage US-based companies face in this respect relates to repatriating profits. If these companies bring foreign profits back to the US, for example, to invest in US R&D, they are taxed at the US corporate rate. Since the US corporate tax rate puts them at a disadvantage from a global perspective, companies may have less incentive to repatriate overseas profits.

Overall, the tax incentives in the US can be described as the weakest in our sample. Companies face high corporate tax rates, a worldwide tax system and do not have access to permanent federal R&D credit.

[89] http://svlg.org/policy-areas/tax-policy/california-tax-incentive-package
[90] http://www.sia-online.org/public-policy/tax/
[91] Times Union (2011). "$650M still an orphan", available at http://www.timesunion.com/business/article/650M-still-an-orphan-2220786.php

#### *3.1.2.4. Tax incentives in Asia*

The tax incentives in the Asian clusters analysed in this study can be described as the most comprehensive and aggressive set of tax incentives across all the clusters. A combination of low corporate rates and a high number of tax incentives, such as R&D tax credits, tax holidays and tax deferrals, ensure favourable tax conditions for companies.

In China, for example, the corporate tax rate is officially 25%. In the Zhongguancun cluster, however, many tax incentives are in place. The main channels of tax incentives are R&D tax credits, tax holidays and tax deferral. While many tax incentives hold for different industries, some specifically apply to semiconductor companies. These measures include the following:

- Newly established chip design companies enjoy ***a two-year tax exemption and a 50% tax reduction in the subsequent three years***;
- Key companies listed in the State's plan that do not benefit from this, ***enjoy a reduced tax rate of 10%;***
- In addition, ***the depreciation period of the equipment may be shortened to three years*** (with approval of the tax authorities); *and*
- Chip producing companies below a certain size may be eligible for ***further tax exemptions***.

Companies accommodated in Hsinchu Science Park (Taiwan) also benefit from high tax incentives. First of all, Taiwan has one of the lowest corporate income tax rates in the world (17%). On top of that, companies in HSP are entitled to a five-year tax holiday. Certain companies are also exempt from import duties, commodity tax and business tax. When exported, all products produced in Hsinchu Science Park and all its labour outputs are exempted from business taxation.

#### *3.1.2.5. Lessons for Europe*

Tax incentives in Europe are relatively strong, especially when compared to the tax positions of companies based in the analysed US clusters. Moreover, some European countries offer both highly favourable tax conditions and generous R&D related tax incentives. Compared to the US, Europe has a considerably more advantageous tax policy for the semiconductor industry. To compensate for the disadvantageous tax system, US states have been shown to be willing to offer extra tax benefits as part of a total incentive package.

The Asian countries, however, are even more generous in granting tax incentives. Moreover, by offering low (or reduced) corporate tax rates, companies based in these clusters are already at an advantage. For Hsinchu Science Park (Taiwan), it was noted by stakeholders that the low corporate tax rate and the extensive tax incentives, such as tax holidays and tax deferrals, were considered to be of key importance for attracting new investments.

The EU and its Member States need to consider the benefits from tax deferrals and other tax incentive packages, understanding that this may help create a global level playing field[92]. Tax holidays of the sort used in the Asian clusters, however, are not allowed in Europe. In response,

[92] https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/1._Framework_Conditions_report_Final.doc.pdf

some countries and regions are already experimenting with innovation-friendly tax incentives, which could be further explored.

### 3.1.3. Favourable trade conditions

An example of favourable trade conditions is the presence of Free Trade Agreements or FTAs. FTAs are agreements between two or more countries to establish a free trade area where commerce in goods and services can be conducted across their common borders without tariffs or hindrances but where (in contrast to a common market) capital or labour may not move freely. European Union has signed FTAs with many countries worldwide.

Favourable trade conditions allow for[93]:

- The reduction of tariff and non-tariff barriers, and specifically eliminating new tariffs on emerging semiconductor devices;
- The removal of impediments to e-commerce;
- Advancing environmental initiatives and trade liberalisation;
- Improving IP protection worldwide;
- Increasing market access internationally; *and*
- Upholding strong anti-dumping laws and effective anti-dumping remedies.

#### *3.1.3.1. The importance of favourable trade conditions for the semiconductor clusters*

Semiconductor products are the result of a complex manufacturing process. During this process, a semiconductor product usually travels across the globe at least twice before being delivered to its final customer[94]. Therefore, free and open international trade is a primary engine of the semiconductor industry's growth and development.

The key trade agreement relevant to the semiconductor industry refers to Information Technology Agreement (ITA). The ITA intended to deal with issues created by technological convergence, i.e. the increasing number of functions performed by some products possibly blurring the principal function of a product. However, in practice the mechanisms under the ITA Agreement for the incorporation of new IT products have not worked effectively. The same refers to the resolution of classification divergences[95]. Among the products not covered by the ITA are DRAM chips and a new class of semiconductor chips. Additionally, evolution in the packaging of certain semiconductor devices – which allows more than one piece of silicon inside a package but does not alter the underlying basic functionality of the product – has caused these products to be reclassified for customs purposes and led to the imposition of duties for the first time in years.

[93] http://www.sia-online.org/public-policy/export-controls/
[94] http://www.eeca.eu/ftg/
[95] http://trade.ec.europa.eu/doclib/docs/2008/september/tradoc_140592.pdf

**Information Technology Agreement (ITA)**

Primary goals of the ITA are increased trade and competition through trade liberalisation for information technology (IT) products, and the global diffusion of information technology. The ITA went into effect in 1997 with originally 29 WTO member countries. It covers over 95% of total world trade in IT products[96]. During the past years, semiconductors and computer trade dominated the composition of ITA. The Internet boom of the 1990s and declining prices for personal computers and semiconductors increased demand and trade flows for these products[97]. The contract is valid for microprocessors, integrated circuits, printed circuits, diodes, resistors, as well as for semiconductor manufacturing equipment: etching and stripping apparatus, vapour deposition devices, sawing and dicing machines for wafers, spinners, ion implanters, wafer transport, handling and storage machines, injection moulds, optical instruments, parts and accessories[98].

Table 3-3 provides an overview of the key findings on favourable trade conditions.

TABLE 3-3: Overview of key findings on policy measures and incentives: Favourable trade conditions

| **1.3 Policy measures and incentives: Favourable trade conditions** | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | EU Member States enjoy internal favourable trade conditions such as free trade and mobility of goods and people.<br><br>Trade in this sector for the EU is dominated by imports, particularly from the US, Japan, China and other East and South-East Asian countries.<br><br>While tariffs are mostly covered, non-tariff barriers (NTBs) are a key issue for the EU industry. |
| Grenoble cluster closely cooperates with international businesses such as the Japanese company Yamatake and the American companies Atmel and Xerox. There is also a partnership between the technology research organisation CEA and the Canadian cluster NanoQuébec. | |
| ***Silicon Saxony (Dresden, Germany)*** | |
| Favourable trade conditions are reported to be crucial for the success of the cluster. GLOBALFOUNDRIES in Silicon Saxony produces chips for companies all over the world which also indicates a clear benefit from having favourable trade conditions. | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| Cluster members are reported to be keen on developing favourable partnerships with other European clusters. Non-European clusters are, however, reported to be less interested, because most SMEs in the cluster do not have the capabilities and manpower to communicate and partner with Asian and American companies. | |
| ***Silicon South West (South West England, UK)*** | |
| FTAs are suggested to be of less importance for the international competitiveness of this cluster. The typical trade route for semiconductor products from the South West is: designed in the South West; possibly co-designed in Cambridge or France; tested in Denmark or Wales; and manufactured in Taiwan. The cluster does not rely on any particular FTAs to conduct these activities. This observation, however, does not hold for the UK in general, where trade conditions play a vital role. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | Next to ITA, US has a bilateral agreement with Korea that covers a broader range of high-tech exports than those covered by the ITA. Moreover, the agreement provides important new |
| Many of the newest chip firms do not get into the manufacturing business at all. They design and market chips, but contract with a larger firm to make them. In many cases, it is an overseas firm that does the manufacturing. | |

[96] Anderson M., Mohs J. (2010) "The Information Technology Agreement: An Assessment of World Trade in Information Technology Products", Journal of International Commerce and Economics available at http://www.usitc.gov/publications/332/journals/info_tech_agreement.pdf

[97] Aizcorbe A. M., Flamm K. and Khurshid A. (2002) "The role of semiconductor inputs in hardware price decline: computers vs. communications", FEDS Working Paper 2002-37 (August 2002)

[98] Anderson M., Mohs J. (2010) "The Information Technology Agreement: An Assessment of World Trade in Information Technology Products", Journal of International Commerce and Economics available at http://www.usitc.gov/publications/332/journals/info_tech_agreement.pdf

| 1.3 Policy measures and incentives: Favourable trade conditions | |
|---|---|
| ***Tech Valley (Albany, US)*** | guarantees for cross-border delivery of computer and related services, management consulting and other tech-related services.<br><br>Semiconductors are the US' largest export. Excessive restrictions suppress the ability of US companies to compete with foreign competitors that do not have the same export-related administrative and bureaucratic burdens. |
| No specific issues or challenges were identified for this cluster regarding favourable framework conditions (see commonalities for the US region). | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)*** | The semiconductor industry plays a crucial role in both countries' economies. By joining the WTO, both countries became part of the ITA agreement which eliminates tariffs on most semiconductor products. |
| China is the largest semi-conductor market in the world. At the same time, Chinese semiconductor exports have accounted for most of the growth in the Chinese semiconductor market. By joining the WTO in 2001, China automatically became part of the ITA agreement. | |
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | |
| Taiwan joined the WTO in 2002, resulting in it becoming part of the ITA agreement and thus eliminating tariffs on most semiconductor products. Taiwan, being a small island economy with a small domestic market, is heavily dependent on exports, particularly on its two main export markets, the US and China. Fabless companies rely on the plentiful foundries in Taiwan. | |

### *3.1.3.2. Favourable trade conditions in Europe*

Trade in this sector for the EU is dominated by imports, particularly from the US, Japan, China and other East and South-East Asian countries. Although the EU is relatively strong in certain electronics markets, it has a negative trade balance in the electronics sector as a whole (105 billion EUR in 2010) and in all sub-sectors apart from measuring devices[99].

A large proportion of global electronics trade (approximately 70% of EU imports and 55% of EU exports) is covered by the Information Technology Agreement (ITA) of 1997. As such, there are no tariffs on the specified products in place. Tariffs, however, remain an issue with non-ITA members and for non-ITA electronic products, which most notably include new product developments[100].

The key motives of the EU to have favourable trade conditions include[101]:

- Opening new markets for goods and services, raising investment opportunities;
- Making trade cheaper (through the elimination and decreasing of all customs duties);
- Accelerating the trade (through facilitating goods' transit through customs and setting common rules on technical and sanitary standards); *and*
- Stabilising the policy environment (through taking joint commitments on areas that affect trade such as IP rights, competition rules and the framework for public purchasing decisions).

[99] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/industrial-goods/electronics/
[100] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/industrial-goods/electronics/
[101] http://ec.europa.eu/trade/creating-opportunities/bilateral-relations/agreements/#organiser

***Non-tariff barriers***

While tariffs are mostly covered, non-tariff barriers (NTBs) are a key issue for the EU industry. Examples of NTBs are burdensome certification procedures and IT encryption requirements, different standards, double testing, lack of protection of IP rights and impediments to access to raw materials (for example, rare earths). Market access problems for services can also have an impact on the trade of goods. Given its relative importance, the high-tech electronics sector is often subject to policies that could distort trade. For example, subsidies on indigenous innovative industries are suggested to encourage foreign investment and technology transfer[102].

An instance where security standards in FTAs play a key role for semiconductor companies concerns the agreement Europe has with China for the encryption of components. Chips for passports and credit cards are obliged to have a certain level of security. This is determined based on certain standards, which are used worldwide. However, the challenge is that China uses its own standards, and this discrepancy can lead to difficulties for European companies wishing to operate in the Chinese market.

Additionally, a discussion is going on concerning the semantic standards for “multi chip modules”. Different parties disagree whether such module is still a chip, a component or a box. The trade agreements for chips are different than those for the import and export of a complete component. Clarity concerning this topic would facilitate international trade by European semiconductor companies.

**EU-Korea Free Trade Agreement[103]**

The Council authorised the Commission in April 2007 to negotiate a comprehensive Free Trade Agreement with the Republic of Korea, with two main objectives: to reciprocally liberalise all trade in goods and services and to tackle existing and future non-tariff barriers to trade. In May 2007, negotiations were launched in Seoul. After eight rounds of talks, the negotiations have been completed and the agreement has been initialled on 15 October 2009. On 9 April 2010, the Commission adopted a proposal for a Council Decision authorising the signature and the provisional application of the FTA - COM(2010)136. The agreement was signed on 6 October 2010, approved by the European Parliament on 17 February 2011 and ratified by the Korean National Assembly on 4 May 2011. It provisionally entered into force on 1 July 2011.

***ESIA Foreign Trade Group***

The ESIA[104] Foreign Trade Group (FTG Group) is a permanent committee within this association aimed at facilitating cooperation among ESIA members. It further seeks to represent foreign trade related issues faced by the European semiconductor industry at both European and global levels.

The FTG is divided in three different working groups: Rules of Origin Working Group, Customs Classification Working Group and Reform of Customs Code Working Group[105]. Together, these working groups aim to achieve simplification of international trade for European semiconductor companies by:

[102] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/industrial-goods/electronics/
[103] http://ec.europa.eu/enterprise/policies/international/facilitating-trade/free-trade/index_en.htm#h2-1
[104] European Semiconductor Industry Association
[105] http://www.eeca.eu/ftg/

- Harmonising working programmes of non-preferential rules of origin (RoO) within the World Trade Organisastion (WTO)[106];
- Reforming preferential origin regimes for the EU[107];
- Frequently revising semiconductor product classifications used in international trade in order to keep them in line with changes in technology[108]; *and*
- Contributing experience, through its member companies, in highly automated and computerised supply chain and customs processing in order to lower administrative and handling costs and shorten transit times[109].

***Favourable trade conditions in the analysed clusters***

When analysing the individual clusters, the following observations can be made. Grenoble cluster closely cooperates with international businesses such as Japanese company Yamatake and American companies Atmel and Xerox. There is also a partnership between the technology research organisation CEA and the Canadian cluster NanoQuébec[110].

Favourable trade conditions are reported to be crucial for the success of the cluster. GLOBALFOUNDRIES in Silicon Saxony produces chips for companies all over the world which also indicates a clear benefit for the company to be based in a location with favourable trade conditions.

With regard to DSP Valley and Eindhoven ASML, cluster members are reported to be keen on developing favourable partnerships with other European clusters. Non-European clusters, however, are reported to be less interested, because most SMEs in the cluster do not have the capabilities and manpower to communicate and partner with Asian and American companies.

In the case of the Silicon South West cluster, FTAs are generally suggested to be of less importance for the international competitiveness. The typical trade route for semiconductor products from the South West is: designed in the South West; possibly co-designed in Cambridge or France; tested in Denmark or Wales; and manufactured in Taiwan. The cluster does not rely on any particular FTAs in order to conduct these activities. This observation, however, does not hold for the UK in general. In 2009, the UK semiconductor industry market was worth 6 billion USD, hosting operations of more than 500 semiconductor firms, 80% of which are foreign-owned[111]. Having favourable trade conditions with the rest of the world is therefore key to the UK semiconductor industry.

[106] http://www.eeca.eu/rules_origin/
[107] http://www.eeca.eu/rules_origin/
[108] http://www.eeca.eu/customs_classification/
[109] http://www.eeca.eu/reform_customs/
[110] "Clusters: a new way to do business in France" Investinfrance.org document available at http://www.consulfrancenouvelleorleans.org/IMG/pdf/INNOVATIVE_CLUSTERS_2007.pdf
[111] Marston L., Shanmugalingam S., and Westlake S. (2010) "Chips with everything: Lessons for effective government support for clusters from the South West semiconductors industry", NESTA, available at: http://www.nesta.org.uk/library/documents/Semiconductorsv10.pdf

**UK Electronics in Japan – Business development mission to Japan**[112]

As part of its support for UK companies for the development of international trade links, in 2008, the UK Trade & Investment (UKTI) planned a business development mission to Japan. This mission provided the UK (micro)electronics companies with a chance to visit potential customers in Tokyo, Yokohama, Osaka and Kyoto. This was of interest to UK companies since many Japanese customers are in need of advanced technologies in the field of microelectronics such as embedded applications. All companies with an interest in electronics (including SoC, semiconductors and value-added services for semiconductor businesses) were invited to participate in these kind of trips. Companies new to the market, as well as companies which already have business contacts in Japan, are expected to benefit from these trade missions.

***Key barriers and challenges***

There are multiple challenges for EU policymakers concerning the establishment of free trade agreements.

Within the Commission's 'Global Europe strategy', particular attention should be paid to ensure favourable trade conditions for the semiconductor industry through bilateral and multilateral means, i.e. to avoid international market distortions, facilitate market access and investment opportunities, improve IPR protection, and reduce the use of subsidies and tariff and non-tariff barriers at the global level. Existing international forums, such as the "Governments/Authorities Meeting on Semiconductors (GAMS)", can be used to address the problems that have been identified[113].

On the basis of the existing situation mainly defined by the ITA and existing FTAs, three main areas need to be addressed: 1) widening of the scope of products that benefit from zero duty treatment and adaptation to new technological developments; 2) geographical widening of duty concessions (to non-ITA/FTA partners), and 3) reducing NTBs. For example, technical barriers to trade (TBT, such as standards) in developed economies constitute important barriers to market access. In the future, TBTs may also become important barriers to trade in emerging markets as the latter begin to develop more sophisticated regulatory norms and voluntary standards[114].

These goals are presently pursued via negotiations in the WTO through the Doha round (sectoral on electronics/electrics and TBT sectoral on electronics), EU proposals for an ITA revision, Free-Trade Agreements (tariffs and TBTs, for example, Korea's FTA), market access activities on NTBs, including the tools of the Market Access Strategy (for example, IT encryption in China), and specific activities such as the plurilateral GAMS, tariffs, NTB, IP rights, and subsidies[115].

[112] Silicon South West Newsletter, Issue 14, February 2008, available at: http://www.google.nl/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=5&ved=0CE4QFjAE&url=http%3A%2F%2Fwww.shin-yokohama.jp%2Fpdf%2F080417d2.pdf&ei=nWOiT5eWM8fg4QTH_pDPCA&usg=AFQjCNGZ22c9ZKnSBY9B6PjWW0rVmh9sfQ

[113] "Preparing for our future: Developing a common strategy for key enabling technologies in the EU", COM(2009)512

[114] See also Woolcock, S. (2007) European Union policy towards Free Trade Agreements, ECIPE WORKING PAPER, available at: http://www.felixpena.com.ar/contenido/negociaciones/anexos/2010-09-european-union-policy-towards-free-trade-agreements.pdf

[115] http://trade.ec.europa.eu/doclib/docs/2011/july/tradoc_148053.pdf

#### 3.1.3.3. *Favourable trade conditions in the United States*

Semiconductors form the largest proportion of exports in the U.S, with more than 80% of US semiconductor sales conducted outside the country[116]. Therefore, free and open international trade is a primary engine of the US semiconductor industry's growth and development.

Similar to Europe, the key trade agreement relevant to the semiconductor industry refers to the ITA. The agreement with Korea, in turn, covers a broader range of high-tech exports than those covered by the ITA. Moreover, the agreement provides important new guarantees for cross-border delivery of computer and related services, management consulting, and other tech-related services, including those conducted through electronic delivery[117].

**US-Korea Trade Agreement**

The US-Korea trade agreement entered into force on 15 March 2012. The US International Trade Commission estimates that the reduction of Korean tariffs and tariff-rate quotas on goods alone will add 10 to 12 billion USD to annual US Gross Domestic Product and around 10 billion USD to annual merchandise exports to Korea. Under the FTA, almost 80% of US exports to Korea of consumer and industrial products become duty, and nearly 95% of bilateral trade in consumer and industrial products will become duty-free within five years. Most remaining tariffs would be eliminated within ten years[118]. Major US exports to South Korea include semiconductors and machinery (particularly semiconductor production machinery)[119]. Major US import items from South Korea include semiconductor circuits. The new trade agreement is also expected to provide US suppliers with greater access to the Korean government procurement market[120].

Additionally, the US semiconductor industry's representatives play an active role in the World Semiconductor Council (WSC). The WSC is also composed of companies in China, Chinese Taipei, Europe, Korea, and Japan. The Governments/Authorities Meeting on Semiconductors (GAMS) comprises of officials from the US Government and officials representing all WSC regions, and convenes once a year to receive the WSC's recommendations and take action.

Since its inception in 1996, the WSC has worked to advance a number of trade issues, including:

- Support for IP protection;
- Full transparency of government policies and regulations;
- Non-discrimination of foreign products in all markets;
- Voluntary and industry-led standards;
- An end to investment restrictions tied to technology transfer requirements; *and*
- Zero duties on multi-chip packages.

For instance, in the US, design offshoring can face barriers related to national security. The US government has placed limits on the export of advanced encryption technology. Chips which employ such technology are difficult to design offshore. Chip design must be compartmentalised, with the

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[116] http://www.sia-online.org/public-policy/export-controls/
[117] High-Tech Trade Coalition's Letter to the Members of Congress of 6 October 2011 available at http://www.sia-online.org/
[118] Office of the United States Trade Representative http://www.ustr.gov/trade-agreements/free-trade-agreements/korus-fta
[119] Cooper W.H., Manyin M.E., Jurenas R., Platzer M.D. (2010) "The Proposed US-South Korea Free Trade Agreement (KORUS FTA): Provisions and Implications", Congressional Research Service Report for Congress 12 November 2010
[120] Office of the United States Trade Representative http://www.ustr.gov/trade-agreements/free-trade-agreements/korus-fta

encryption block designed only in the US Otherwise, government approval, subject to possible delays, must be obtained in advance[121].

Despite the abovementioned measures, the US international trade system is reported to face several challenges. Excessive restrictions suppress the ability of the US companies to compete with foreign competitors that do not have the same export-related administrative and bureaucratic burdens. Time-to-market is critical in international competition, and delays and backlogs, even of a few days, force buyers to look elsewhere.

#### *3.1.3.4. Favourable trade conditions in Asia*

China is the largest semiconductor market in the world, importing more than 50% of global semiconductor shipments[122]. At the same time, Chinese semiconductor exports have accounted for most of the growth in the Chinese semiconductor market[123]. Moreover, IC manufacturing and IC packaging and testing, which are both relatively more export dependent, are areas of the value chain with particularly high importance in China as a whole. This strong dependency on exports poses a challenge to maintain favourable trade conditions. By joining the WTO in 2001, China automatically became part of the ITA agreement.

Taiwan joined the WTO on 1 January 2002. WTO membership meant that Taiwan now also needed to comply with the ITA. Taiwan is a small island economy with a small domestic market, and is thus strongly dependent on exports, with end-user industries usually located in China, Europe or the US For example, in the US, there are the big end-user companies such as Intel and IBM. Moreover, fabless companies rely on the plentiful foundries in Taiwan. Favourable trade conditions are thus key for the Taiwanese semiconductor industry.

The export side of the Taiwanese economy strongly depends on a limited number of markets (both overall exports and electronics exports), where the US accounts for 20% of Taiwan's overall exports and electronics exports. China, including both the Mainland and Hong Kong, accounts for 36% of Taiwan's overall exports and 32% of the country's electronics exports. These illustrate the relatively high level of concentration of Taiwanese export markets. Consequently, this subjects the country to considerable terms-of-trade risks, including the possibility of competitive devaluation and contagion. Furthermore, Taiwan's rising dependence on Mainland China might lead to the lowering of its bargaining power vis-à-vis other political and economic relations with the Mainland.[124].

#### *3.1.3.5. Lessons for Europe*

On the basis of the existing situation mainly defined by the ITA and existing FTAs, three main areas need to be addressed in Europe: 1) widening of the scope of products that benefit from zero duty treatment and adaptation to new technological developments; 2) geographical widening of duty concessions (to non-ITA/FTA partners), and 3) reducing NTBs.

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[121] Brown C., and Linden G. (2009) "Chips and Change: How crisis reshapes the semiconductor industry", Massachusetts Institute of Technology
[122] http://www.sia-online.org/public-policy/export-controls/
[123] PwC (2011) "Continued growth: China's impact on the semiconductor industry, update 2011".
[124] Chew et al. (2007): "Taiwan: Semiconductor Cluster", Harvard Business School, Massachusetts, US

The competitiveness of companies and products should be the key determinant for market success, not the intervention of governments such as creating barriers to market access and international trade. Instead, the EU and its Member States should actively pursue policies that ensure the access of the European semiconductor products and solutions to foreign markets, such as removing tariff and non-tariff barriers, in order to promote the growth of semiconductor markets.

Specifically, a new future EU-US trade agreement is suggested as a means of making regulatory regimes more compatible across the Atlantic by limiting regulatory costs and 'red tape'. It is further suggested that one of the aspects of such agreement should focus on market access in third countries, which is linked to the various local innovation policies developing across the world and the obstacles for the global deployment of semiconductors. Incorporating such aspects in the agreement could set a golden standard that could then be replicated in the following trade agreements and that would allow the avoidance of discrimination relating to foreign semiconductor products. Such an agreement could also include a possible reduction of NTBs.

Finally, the use of Trusted Platform Modules (TPMs)[125] was suggested to be an important method employed by the rights holders when offering content to consumers. Content protected by TPMs represents an increasingly larger share of all of the content distributed today. Nevertheless, the number and the amounts of levies have increased in recent years, despite the requirement that any imposition of levies should take into consideration the use of TPMs. It was suggested that device-based levies systems continue to distort and fragment a single digital market, and need to be replaced. At the same time, there are technologies that allow a rights holder to receive compensation directly from the consumer. Such technologies are considered to be more aligned with the principles of a single digital market conducive to a dynamic licensing environment that permits and encourages innovation and new business models. Therefore, encouraging such alternative systems would not only ensure more fair and reliable compensation for creators, but also more and better legal offers of content for consumers, thereby discouraging piracy.

### *3.1.4. Pre-commercial public procurement*

Pre-commercial procurement is an approach for procuring R&D services which enables public procurers to[126]:

- Share the risks and benefits of designing, prototyping and testing new products and services with the suppliers, without involving state aid;
- Create the optimum conditions for wide commercialisation and take-up of R&D results through standardisation and/or publication; *and*
- Pool the efforts of several procurers.

The basic idea behind pre-commercial public-procurement is that it targets innovative products and services for which further R&D needs to be done while the technological risk is shared between procurers and potential suppliers.

[125] The Trusted Platform Module offers facilities for the secure generation of cryptographic keys, and limitation of their use. It also includes capabilities such as remote attestation and sealed storage.
[126] http://ec.europa.eu/information_society/tl/research/priv_invest/pcp/index_en.htm

By acting as technologically demanding first buyers of new R&D, public procurers can drive innovation from the demand side. This enables public authorities to innovate the provision of public services faster and creates opportunities for companies to take international leadership in new markets[127].

#### 3.1.4.1. *The importance of pre-commercial public procurement for the semiconductor clusters*

Pre-commercial public procurement ensures (early) market adoption and stimulates local sales. This can for instance foster innovation by offering an outlook of initial success. Moreover, it may give other companies an incentive to be early adopters given that a certain technology has already found its way to the market. Procurement in general also provides support to indigenous companies of the cluster by directly supporting their core business. Pre-commercial public procurement can therefore play a considerable role in the development of the semiconductor industry.

Table 3-4 provides an overview of the key findings on pre-commercial public procurement.

TABLE 3-4: Overview of key findings on policy measures and incentives: Pre-commercial public procurement

| 1.4 Policy measures and incentives: Pre-commercial public procurement | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | The current pre-commercial procurement scheme being discussed at European levels follows US approaches that already have been implemented and successfully used for many years.<br><br>European pre-commercial public procurement is still underutilised. Although several initiatives are already in place, they are reported not to be successful yet. |
| Public procurement in France was particularly important in the 1980s for fields such as nuclear power plants and high-speed trains; however, it is reported not to play any role in the current semiconductor industry in the cluster. | |
| *Silicon Saxony (Dresden, Germany)* | |
| The state is Germany's biggest buyer, due to its spending amounting to approximately 12% of GDP. Introduced in 2006, the "High-Tech Strategy for Germany" integrates all of the German government's measures in the fields of innovation and technology policy. However, no information was found on the importance of this type of procurement for the cluster. | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| Innovative procurement practices by the Belgian and Dutch governments in the cluster were only started two years ago. No member companies within DSP Valley and Eindhoven ASML, to date, have made use of or benefited from this type of pre-commercial public procurement. | |
| ***Silicon South West (South West England, UK)*** | |
| Pre-commercial public procurement has had no significant influence for the development of the SSW cluster. The Small Business and Research Initiative Programme, which is particularly suited for SMEs and early stage business, has not been as effective in the UK as compared to the US This has been attributed to the absence of leadership and coordination. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | The US public sector spends billions of USD per year in the procurement of R&D, an amount which is 20 times higher than in Europe and represents approximately half of the overall R&D |
| Massive procurement efforts by the federal government in the 1950s-1960s helped improve chip manufacturing processes and reduce the price of these chips enough to make them widely applicable and accessible. Silicon Valley was built on government-subsidised procurement preference, not on venture capital. | |

[127] COM(2007) 799 Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe

| 1.4 Policy measures and incentives: Pre-commercial public procurement | |
|---|---|
| *Tech Valley (Albany, US)* | investment gap between the US and Europe. This has often played an important role in improving the quality of public services and in the emergence of globally competitive companies. |
| While theoretically public procurement could be provided, no indications of this kind of policies were found. As the technology being developed in the cluster or used in the current manufacturing is in global demand, public procurement measures here are reported to be of minor importance. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| Individual descriptions | Commonalities |
| *Zhongguancun (Beijing, China)* | No commonalities were found. While procurement is an important aspect of the innovation strategy in China, the role of procurement for the semiconductor industry is highly limited in Taiwan. |
| Beijing is one of the most active regions in public procurement. Current procurement policies aim at stimulating the creation of domestic IP. For this purpose, they accredit products on a number of requirements, such as whether the IP is fully owned by a domestic firm. The accredited products are then used to compile a list of products that can be used for government procurement. | |
| *Hsinchu Science and Industrial Park (Hsinchu, Taiwan)* | |
| None is being offered at the moment. Foundries play a large role in the cluster, and such well-established manufacturing facilities that focus on intermediate products are less likely to benefit from public procurement as compared to innovative start-ups. As the result, the effect of public procurement in HSP is limited. | |

#### *3.1.4.2. Pre-commercial public procurement in Europe*

The key motives of both EU and national level initiatives for (pre-commercial) public-procurement are[128]:

- Reinforcing the innovation capabilities of the EU;
- Improving the quality and efficiency of public services;
- Sharing the technological risk between procurers and potential suppliers;
- Accelerating technology adoption; *and*
- Being a lead customer for, especially small, companies for development of their idea/prototype.

The current pre-commercial procurement scheme being discussed at European level follows US approaches that already have been implemented and which have successfully been used for many years[129]. Pre-commercial public procurement in Europe is still not a popular measure. At the same time, reducing time to market by developing a strong European home market for innovative products and services is key for Europe to create growth and jobs in quickly evolving markets such as ICT. The aims of this policy are the creation of early stage demand for innovation of emerging technologies, reinforcement of the innovation capabilities of the EU and improvement of quality and efficiency of public services[130]. The European Parliament's resolution of June 2007 on the transposition and implementation of public procurement legislation aimed to encourage the wider use of pre-commercial procurement in the EU[131].

When analysing the individual clusters, the following observations can be made. In the case of Grenoble, public procurement is reported not to play any role in the current semiconductor industry

[128] http://www.innovateuk.org/deliveringinnovation/smallbusinessresearchinitiative/whatissbri.ashx
[129] Edler, J., and Georghiou, L. (2007) "Public procurement and innovation – Resurrecting the demand side", Research Policy, Issue 36, 949-963, available at: http://dimetic.dime-eu.org/dimetic_files/EdlerGeorghiou2007.pdf
[130] http://ec.europa.eu/information_society/tl/research/priv_invest/pcp/index_en.htm
[131] "Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe", COMMISSION OF THE EUROPEAN COMMUNITIES December 2007, Brussels

in the cluster, though in France it was particularly important in the 1980s for fields such as nuclear power plants and high-speed trains.

As for DSP Valley and Eindhoven ASML, the importance of public procurement for semiconductor companies in the cluster, as opposed to market mechanisms and simple supply and demand, is relatively low. Most cluster companies are not directly involved with pre-commercial public procurements, because these projects often involve the procurement of integrated or end-products and services. Most companies supply components for these integrated products and participate in such projects through consortia.

Pre-commercial procurement also had no significant influence for the development of the Silicon South West cluster. The Small Business Research Initiative (SBRI) programme has not worked as well in the UK as it did in the US Suggested reasons refer to the absence of leadership and coordination. It is reported to be unclear to cluster members which public body is actively executing public procurement functions. Pre-commercial public procurement in the US is mainly aimed at developing key capabilities for the future, whereas in the UK, it is more aimed at procuring for the lowest price. For the semiconductor industry in the UK, public procurement is especially ineffective, because semiconductor products are often embedded in a system. For instance, if they are embedded in health care equipment, there might be no UK vendors that supply these products at all. Stimulating UK semiconductor companies through procurement then becomes difficult.

***Key barriers and challenges***

Key barriers and challenges concerning pre-commercial public procurement at the EU level are:

- Informing SMEs of public procurement possibilities;
- Improving access to public procurement projects (especially for SMEs);
- Better planning of government procurement that would help to address some of the problems suppliers face, by offering greater scope for capacity planning[132]; *and*
- Low public procurement budget for the EU, in comparison with the US, for example, due to[133]
    - Lack of awareness on how to optimise risk-benefit balance for procurer and supplier;
    - Lack of knowledge of how to fit this within the legal framework for R&D procurement; *and*
    - Fragmentation of demand.

Additionally, public purchasers in Europe tend to opt for exclusive development. Exclusive development means that the public purchaser reserves all the results and benefits of the development exclusively for own use. This may hamper innovation. The exclusive assignment of rights to the public purchaser takes away the incentive for companies to invest in further commercialisation. In most cases however, “exclusiveness” of project results is not indispensable for public purchasers as the public purchaser is only one of many potential users of the developed solution. Moreover, public purchasers often overlook the additional costs and efforts needed to reap the benefits of the results. Unless the public purchasers have a mandate and specific plans to

[132] “Innovation report, competing in the global economy: the innovation challenge”, DTI, December 2003, available at: http://webarchive.nationalarchives.gov.uk/+/http://www.dti.gov.uk/files/file12093.pdf
[133] Bos, L. (2008) “Pre-commercial procurement, driving innovation to ensure high quality public service in Europe”, available at: ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/pcp/20090616-lieve-bos_en.pdf

commercially exploit the research results, there is often no reason to bear high costs and risks of exclusive development[134].

#### *3.1.4.3. Pre-commercial public procurement in the United States*

The US public sector spends billions of USD per year in R&D procurement, an amount which is 20 times higher than in Europe and represents approximately half of the overall R&D investment gap between the US and Europe[135]. This has often played an important role in improving the quality of public services and in the emergence of globally competitive companies. The difference in R&D procurement expenditure between the US and Europe is mainly due to disparities in defence/space budgets.

In the case of Silicon Valley, government procurement in the early days of the semiconductor industry (1950s – 1960s) provided a valuable stimulus to technological development and industry growth. In addition to providing generous contracts, the government served as a reliable first customer providing companies with early markets. Grenoble cluster, in turn, is reported to not have benefited from public procurement in the field of microelectronics. The key motives of the government were to increase the nation's innovative capacity and to gain competitive advantage. Semiconductors represented a new enabling technology that was driving complex electronic processes which, in turn, determined the nation's competitiveness.

Today, government procurement is on a constant decline in Silicon Valley, dropping 2% over the last 15 years, while government procurement in other cities such as Washington D.C. and Huntsville, Alabama has risen 7.2% and 4.5% respectively over the same period of time[136]. In 2008, Silicon Valley received 6.7 billion USD from the federal government, which was 1.3% of the total dollars dispersed[137]. No data is, however, available on how much of it was allocated to the semiconductor industry.

In the case of Tech Valley, while public procurement could theoretically be provided, no indications of this kind of policies were found. As the technology being developed in the cluster or used in the current manufacturing is in global demand, public procurement measures are reported to be of minor importance to the cluster.

#### *3.1.4.4. Pre-commercial public procurement in Asia*

Procurement is an important aspect of China's innovation strategy, as government purchases are a major source of funding for companies engaged in R&D. Beijing is one of the most active regions in innovation-oriented public procurement in China, along with Shanghai, Tianjin, Guangdong, Jiangsu, Shandong and Zhejiang. Current procurement policies aim at stimulating the creation of domestic IP. For this purpose, they accredit products on a number of requirements, such as whether the IP is fully owned by a domestic firm. The accredited products are then used to compile a guideline of products that can be used for government procurement. Since one of the key challenges the cluster faces

[134] "Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe", EC, December 2007, Brussels
[135] "US defence R&D spending: an analysis of the impacts", EURAB report, PREST, 2004, quoted in COM(2007) 799
[136] http://www.readwriteweb.com/start/2010/02/silicon-valley-2009-job-loss.php
[137] http://www.sanjoseinside.com/news/entries/02_15_10_silicon_valley_index/

concerns a general lack of domestic IP in China, such policies may turn out to be crucial for the future development of the cluster. The key incentive for offering public procurement is to boost the creation and commercialisation of domestic technologies and ideas.

Although the proportion of regular public procurement expenditure in GDP has expanded from 0.59% in 2001 to 2% in 2008, it is still considerably lower than that of many OECD countries[138]. This also suggests that innovation-oriented public procurement in China might have even greater potential if a higher percent of the budget is allocated to public procurement as a whole.

In Taiwan, no intervention in the operations of the private sector in the form of pre-commercial public procurement is reported to take place. Well established manufacturing facilities that focus on intermediate products are less likely to benefit from public procurement as innovative start-ups. As such, the effect of pre-commercial public procurement in HSP cluster is limited, but it may be considered as an option in the future.

#### *3.1.4.5. Lessons for Europe*

US and China use pre-commercial public procurement of innovation strategically as a means of providing a strong home market for their domestic supplier base in well-defined areas of international competitiveness. European pre-commercial public procurement, in turn, is still underutilised as a means of boosting research and innovation in semiconductors.

The public sector can be a major catalyst for applied research and innovation. However, forcing below-quality solutions to market (within the public sector) is not favourable for customers or suppliers. A possible solution could be to create a 'public sector incubator' where products could be properly tested before any formal deployment.

Public procurement instruments need to be developed to promote solutions which utilise semiconductor technology to address Europe's grand challenges (for example, energy efficiency, mobility, cyber-security, and health). This would help to develop the ability and capacity of European eco systems, which would include semiconductor companies, to develop and deliver these solutions. In turn, these public procurement instruments should support both SMEs and large companies to ensure a broad-based economic impact.

### *3.1.5. Access to finance*

Semiconductor companies in general find it hard to raise funding due to several industry-specific characteristics. The cost of designing and manufacturing a new chip is rising as chip sizes become smaller, and often an investment of about 10 to 50 million EUR is needed just to find out if the design is going to work. The sale of semiconductor companies, in turn, generally pays a lower multiple than that of a software or Internet company with similar revenue and growth. As a result, potential investors have to take on more risk with less potential upside. Besides the risk that the product would not work or that it would be too expensive to build, there is a high risk that even companies meeting their milestones would not be able to get funded. These reasons make investors even more sceptical thereby creating additional difficulties in attracting funds.

[138] OECD (2008)." OECD Reviews of Innovation Policy – China". available at http://www.oecd.org/document/44/0,3746,en_2649_34273_41204780_1_1_1_1,00.html

As a result, it is often only the biggest players who can keep up with state-of-the-art operations, as the cost of entry is extremely high. This has led to established players having a distinct advantage over smaller firms. However, despite this, we are observing a new emerging trend, where semiconductor companies are forming alliances to spread out the costs of manufacturing.

#### *3.1.5.1. The importance of access to finance for the semiconductor clusters*

In the high-tech industry, capital, in particular venture capital, is often regarded as essential. Young firms in high-tech areas only expand some time after they have been set up, but when they do so, these firms belong to the principal generators of economic growth and employment. These innovative firms should therefore be assisted in their initial phase of development with capital in order to reach high levels of development successfully. According to empirical studies, firms which profit from venture capital achieve much higher innovation performance. The increased competition which accompanies the increased importance of innovative firms is highly beneficial and can also propel more established enterprises to increase their level of innovation and thus contribute to growth more intensely. Another empirical study held in Europe indicates that firms assisted with venture capital achieve substantially higher growth rates than older and more established enterprises which have not experienced such assistance[139].

An extensive body of academic research suggests that access to finance plays a crucial role in boosting innovation. This role has two dimensions: accelerating growth, and ensuring long-run success. Firstly, investors provide the capital to speed the development of companies. Secondly, evidence suggests that the early participation of venture firms helps innovators sustain their success long after their company goes public and the venture capitalists move on[140].

In 1990s and early 2000s, venture capitalists were interested in funding traditional fabless semiconductor design companies. Nowadays, however, VCs seem to be more interested in pre-funding start-ups that are in the proof of concept stage of Field-Programmable Gate Arrays (FPGAs), which are basically off-the-shelf components. Those companies, however, put the added value in the embedded software operating the hardware. The development process for these products is significantly shorter, and therefore less risky for VCs. The idea is to ultimately prove the concept and execute it in hardware such as Application-Specific Integrated Circuits (ASICs). This can still be counted to the field of semiconductor design, but with a stronger focus on embedded software. This is done alongside traditional fabless design, in order to adjust to the current financial markets.

With the current development of 450mm manufacturing technology and the increasingly higher costs of doing so, foundries will need to be upgraded in the future. As existing manufacturing tools would no longer be compatible with the new technology, new equipment will need to be developed and procured. As equipment costs are expected to rise along with the cost of the technology itself, the availability of finance would need to keep growing in order to supply the large capital injections demanded by such partners.

Table 3-5 provides an overview of the key findings on access to finance.

[139] "The market for venture capital in Germany", Deutsche Bundesbank, Monthly Report October 2000 available at http://www.bundesbank.de/download/volkswirtschaft/mba/2000/200010mba_art01_venturecapital.pdf

[140] http://www.freakonomics.com/2009/12/28/can-public-funded-entrepreneurship-work-a-qa-with-the-author-of-boulevard-of-broken-dreams/

TABLE 3-5: Overview of key findings on policy measures and incentives: Access to finance

| 1.5 Policy measures and incentives: Access to finance | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)***<br>Examples of funding initiatives: Espace Entreprendre (providing advice, training and mentoring to entrepreneurs), the Grenoble Angels association and "Forum 4i" initiatives that increase access to seed capital, Grenoble Angels network Oser l'entreprise ("Daring Enterprise"). Grenoble Chamber of Commerce and Industry (CCIG) is supporting activities for the innovative enterprises. Its support has increased in the recent years. The level of funding available in the cluster is however reported to be insufficient. | There is insufficient level of venture capital available in the European clusters. This leads to deprivation of the innovative activities and slower growth of SMEs, and the whole financing burden is often placed on the public funding.<br><br>Key barriers and challenges include:<br>• Complicated administrative requirements for companies in the clusters. It is especially difficult for smaller companies to cope with these requirements;<br>• Difficulties in striking the balance between what the founders/owners demand for their shares and what the venture capitalists are willing to pay. This often creates delay in the process of financing; *and*<br>• High fragmentation of the subsidy landscape in Europe. |
| ***Silicon Saxony (Dresden, Germany)***<br>Various types of finance are available to the cluster members including seed capital, angel capital and a pension scheme as a capital source. For their pensions, employees waive part of their salary and make it available to the company. VC funding until now has been rather limited. Up to 80% of the participating enterprises use public funds for their corporate financing, and venture capital is of less importance. | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)***<br>Availability of financial instruments such as seed capital and venture capital in the cluster can to a certain extent compete with other top regions in Europe, but lags behind UK and US regions. For large corporations within the cluster, access to venture capital is almost solely important if a new technology is developed through a spinout. For internal projects in multinationals, VCs are reported to be less important. | |
| ***Silicon South West (South West England, UK)***<br>VC is especially important for the cluster's development, as the cluster's vibrant start-up community needs funding to overcome the high capital requirements of the industry, particularly in the beginning. A key challenge is the shortage of VC, with venture capitalists either investing in existing portfolio companies and not in the more risky start-ups, or diverting their investments to other industries due to poor exit sales of UK semiconductor companies in the past. Another challenge is the lack of growth funding to develop successful start-ups and SMEs into multinationals. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)***<br>Silicon Valley people are stock-option individuals. Almost everyone works for options in Silicon Valley. Venture capitalists play a more active role in Silicon Valley than in other regions of the US and the world. However, while venture capitalists are massively investing money into social networking, e-commerce and online-game companies, investments in chipmakers are currently hitting a low point. | Investments in chipmakers are currently hitting a low point. Venture financing of US semiconductor companies has considerably dropped in the last few years.<br><br>Nowadays, most US companies do not consider manufacturing their own products and choose to outsource it to, for example, Taiwanese businesses instead. |
| ***Tech Valley (Albany, US)***<br>The cluster is primarily driven by major corporations such as Intel, IBM and GLOBALFOUNDRIES, with ample available funds. The local government has showcased extensive public support for a wide range of (mostly capital intensive) projects. For start-ups, the State of New York provides a number of initiatives to help raise capital, which includes public funding. Furthermore, several VCs are located in Tech Valley. Access to finance in the cluster is highly dependent on the presence of major players. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)***<br>There are different kinds of capital available in the cluster. In order to alleviate the financing difficulty of the enterprises in Zhongguancun Science Park, the Administrative Committee of Zhongguancun Science Park, Beijing Zhongguancun Finance Group, banks, venture capital firms and intermediary service institutions have jointly set up the Zhongguancun Venture Financial Service Platform. Furthermore, there is a vibrant venture capital community in the cluster. Zhongguancun's Science Park accounted for one-third of all venture capital cases in China in 2011. | A traditionally strong VC industry in Taiwan (since early 1980s) and a quickly growing VC industry in China indicate a strong presence of capital in this region.<br><br>The current state of the Chinese VC industry is far from completely developed, but the recent trends |

| 1.5 Policy measures and incentives: Access to finance | |
|---|---|
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | suggest growth at a tremendous pace. |
| The National Development Fund of the Executive Yuan is a government fund utilised to invest in emerging technology industries, for example, in the early development phases of TSMC. Financial resources have also come from the side of the "reverse" brain drain, with thousands of overseas Chinese engineers returning to Taiwan to work or start companies. | The Taiwanese venture capital industry is the third most active venture capital market in the world, and has been a stable source of funding for SMEs. |

### *3.1.5.2. Access to finance in Europe*

The revenues in the in the high-tech sector are earned much later after the initial investment has been done. There is therefore a need for substantial and long-term financing. However, there is currently an insufficient level of venture capital available in the European clusters. This leads to a deprivation of innovative activities and slower growth of SMEs, with the whole financing burden often placed on the public funding[141]. Therefore, in Europe, the public authorities have a role to play in ensuring growth in this type of private financing, particularly in the high-tech sector. One of the biggest challenges in the clusters is suggested to be the need to increase the level of private venture capital.

When analysing the individual clusters, the following observations can be made. In Grenoble, the companies are reported to have an opportunity to profit from a number of financing alternatives: venture capital, seed investors/incubators, business angels and public capital. Many funding activities are supported by Grenoble Chamber of Commerce and Industry (CCIG), which has increased its support in the recent years. Nevertheless, the level of finding available in the cluster is reported to be insufficient.

**Venture Capital Forum in Grenoble: Forum 4i[142]**

The 4i Forum plays a vital role in seeking out the most innovative technological projects. The Venture Capital Forum allows project proposers to meet venture capital companies who may be able to help them in their development. One of the objectives of Forum 4i is to arrange a series of personal, confidential meetings under one roof and on the same day, between innovative start-ups which are either in the process of being created or which have just been launched, and venture capital companies. Since the first Forum in 1998, more than 130 projects have been presented to venture capital companies with a view to raising funds. To date, more than 96 companies are still in business and have developed their potential.

Several activities are organised around the event including workshops, designed to give project proposers information on strategic subjects relating to the creation and development of their activities. These are held two or three months before the Forum and take place in the Grenoble Chamber of Commerce and Industry. During the event, the technology showcase, which is increasingly successful each year, is a popular place for researchers, economic players and investors to meet and talk.

In the case of Silicon Saxony in Dresden, various types of finance are reported to be available to the cluster members and include seed capital, angel capital and a pension scheme as a capital source. For their pensions, employees waive part of their salary and make it available to the company. The company invests the funds and uses the capital gains to fund their employees' pensions. For SMEs, this kind of company pension scheme could become an alternative to bank loans which would also yield attractive returns for the employees. As for venture capital (VC) funding, until now, it has been

[141] OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development
[142] http://actu-cci.com/en/Special-features/Exhibition/CCI-Grenoble-start-ups-and-investors-meet-in-Grenoble

rather limited. Up to 80% of the participating enterprises use public funds for their corporate financing, and venture capital is of less importance. A study indicated that less than 10% of the enterprises receive VC, even though they are ready to accept such funding[143].

Member companies in the DSP Valley and Eindhoven ASML cluster are reported to have access to both private and public financial sources (for example, seed capital, venture capital, government funds and EU Structural Funds). Availability of financial instruments such as seed capital and venture capital in the cluster can to a certain extent compete with other top regions in Europe, but lags behind regions in the UK and US[144]. For large corporations within the cluster, access to venture capital is almost solely important if a new technology is developed through a spinout. If enough interested venture capital investors can be found, spinning out a technology into a separate new company is considered to be a viable strategy. For internal projects in multinationals, VCs are reported to be less important.

As for the Silicon South West cluster, most of the available funding in the region has come from either venture capitalists or foreign multinationals. Due to strict European control on State Aid to industry, direct government funding has been limited in the cluster. One of the characteristics of the Silicon South West cluster is a vibrant start-up community[145]. Without funding, this feature might disappear. To survive in the current economic climate, initiatives such as facility sharing and payment for usage concerning research equipment could assist resource-constrained start-ups.

The level of venture capital in Silicon South West cluster is reported to be significantly inadequate at the moment. With some investment firms pulling out of the sector altogether, the climate is worsening. Start-up capital is in short supply, which might prevent small firms from commercialising their ideas and technologies. *Those venture capitalists that maintain their investments in the semiconductor industry, mainly invest in existing portfolio companies and not in the more risky start-ups*. Furthermore, another reason why VCs are diverting their investments to other industries is because exit sales of UK semiconductor companies in the past have not been attractive. Companies like PicoChip and Icera, were acquired by large American multinationals before they could reach an initial public offering. Returns for venture capitalists were therefore negligible.

The biggest challenge for the cluster overall, however, is the lack of growth funding to develop big companies in the future. The levels of investment made by existing programmes are too low to develop successful start-ups and SMEs into multinationals. Although several companies have the potential to develop into multinationals, it is uncertain whether they can do this in the current funding climate[146]. Finally, navigating the funding maze costs managers substantial amounts of time as each programme has specific aims in mind and these change frequently[147].

***Key barriers and challenges***

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143 "The market for venture capital in Germany", Deutsche Bundesbank, Monthly Report October 2000 available at http://www.bundesbank.de/download/volkswirtschaft/mba/2000/200010mba_art01_venturecapital.pdf

144 "Engineering the Future, expanding the innovation ecosystem; talent, knowledge and connectivity", ELAt & Brainport Operations B.V., 2008

145 Yearbook 2009-10, National Microelectronics Institute, 2009, available at: http://www.nmi.org.uk/assets/files/annual-reports/NMI%20Yearbook%202009-10%201_1.pdf

146 Marston L., Shanmugalingam S., and Westlake S. (2010) "Chips with everything: Lessons for effective government support for clusters from the South West semiconductors industry", NESTA, available at: http://www.nesta.org.uk/library/documents/Semiconductorsv10.pdf

147 http://www.nmi.org.uk/microelectronics

Different challenges and barriers were identified in relation to funding:

- Access to European funding is especially hampered because of the ***complicated administrative requirements*** for companies in the clusters. It is especially difficult for smaller companies to cope with these requirements.
- It is often ***difficult to strike a balance between what the founders/owners demand for their shares and what the venture capitalists are willing to pay***. This often creates delay in the process of financing.
- Some companies complain that the ***subsidy landscape in Europe is too fragmented*** to be of any support.

The amount of risk capital available to SMEs involved with semiconductors (and KETs in general) in Europe is considered to be too low, but this challenge can be countered by providing targeted and increased support to the semiconductor industry from the EU Community Budget, the European Investment Fund and European Investment Bank. This support from EU government bodies can take the form of providing a package of financial instruments to cover different company sizes and structures (for example, loans, guarantees, grants and tax incentives) aimed at increasing the attractiveness for the private sector to invest in European KETs product development activities and globally competitive manufacturing facilities[148].

#### *3.1.5.3. Access to finance in the United States*

While venture capitalists are massively investing money into social networking, e-commerce and online-game companies, investments in chipmakers are currently hitting a low point. Venture financing of US semiconductor companies dropped 36% through the first three quarters of 2010 to 894.9 million USD, down from 1.39 billion USD in the same period in 2008, according to data from the National Venture Capital Association. In 2009, venture capitalists invested a total of 863.8 million USD in chip companies, the lowest level since 1998[149].

Nowadays, most US companies often do not consider manufacturing their own products and choose to outsource it to, for example, Taiwanese businesses instead. In 2005, Taiwan surpassed the US in terms of chip production and has been adding to its lead ever since. Another reason for investors to be increasingly hesitant about chipmakers refers to dramatic swings in demand for electronics. The volatile nature of the industry means that a company looking to raise money needs to be profitable and have high-profile customers. Since the beginning of 2009, more semiconductor companies have gone public in China than in the US In 2009, Chinese financial markets have provided more than 80% of all chip IPO funding[150].

In the case of Silicon Valley, networks of engineers, entrepreneurs, and wealthy investors were crucial to the development of venture capital. By the early 1980s, venture capital in Silicon Valley was dominated by individuals who had migrated from industry rather than finance. Venture

[148] "High Level Group on Key enabling Technologies (HLG KET)", Working Group on financial instruments, May 2011
[149] http://www.bloomberg.com/news/2010-12-16/silicon-valley-no-longer-reflects-name-as-investors-shun-chips.html
[150] http://www.bloomberg.com/news/2010-12-16/silicon-valley-no-longer-reflects-name-as-investors-shun-chips.html

capitalists play a more active role in Silicon Valley than in other regions of the US and the world[151]; however, increasingly less of these investments are reported to be allocated to the semiconductor industry.

**Stock-option culture of Silicon Valley[152]**
Silicon Valley people are stock-option individuals. Almost everyone works for options in Silicon Valley. There is even one recruiter who specialises in finding "employees without paychecks" searching for workers who will work for 100% stock options until the start-up secures its first round of funding. It is not just the employees. Services will also defer payment until a start-up is backed by investors. Many building owners have made their money not from office rents, but by taking equity stake instead of monthly rent checks. Suppliers will also take an equity stake instead of cash payment for equipment.

As for Tech Valley, the cluster is primarily driven by major corporations such as Intel, IBM and GLOBALFOUNDRIES, with ample available funds. Moreover, the local government has showcased extensive public support for a wide range of (mostly capital intensive) projects. For start-ups it may be a different case. The State of New York, however, provides a number of initiatives to help companies raise capital, including public funding. Furthermore, several VCs are located in Tech Valley. A range of financial institutions regulated by US law ensures quality banking facilities in the area.

While the state may offer many funding programmes and initiatives to help raise funds, the critical investments require support from the leading players in the cluster. IBM in particular has showcased its commitment to the region on many occasions over the past few decades. If, however, economic conditions in other states or countries become more beneficial to these players, there is a threat that they choose to take their investments elsewhere. As many of the critical investments will continue to require the presence of these dominant players, it is crucial for Tech Valley to keep, and possibly expand, the activities of these players in the cluster.

#### *3.1.5.4. Access to finance in Asia*

The current state of the Chinese VC industry is far from being completely developed, but recent trends suggest that the situation is getting better each year. Beijing is one of the key beneficiaries of Chinese VC, and the market for these funds is growing strong. Between the first half of 2010 and the first half of 2011, total VC increased approximately four times[153], and it keeps growing.

There are different kinds of capital available in the Zhongguancun Science Park cluster, and there is reported to be a relatively vibrant venture capital community. In order to alleviate the financing difficulty of the enterprises, the Administrative Committee of Zhongguancun Science Park, Beijing Zhongguancun Finance Group, banks, venture capital firms and intermediary service institutions have jointly set up the Zhongguancun Venture Financial Service Platform[154]. The platform aims to

[151] Castilla E.J., Hwang H., Granovetter M., and Granovetter E. (2000) "Social Networks in Silicon Valley", Chapter 11 in "The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship", edited by Lee C.-M., Miller W.F., Rowen H., and Hancock M., Stanford: Stanford University Press

[152] http://wisepreneur.com/entrepreneurship/what-makes-silicon-valley-so-special-for-entrepreneurs-start-ups-and-innovation

[153] Jansen, G. (2012). "De venture capital-industrie in China", TWA, available at https://www.agentschapnl.nl/sites/default/files/bijlagen/TWA%20China%20-%20Venture%20capital-industrie%20in%20China.pdf

[154] http://en.zgc.gov.cn/2011-11/10/content_14079593.htm

integrate the enterprises resources in the Park and to build a uniform financing service application channel.

**Garage Cafe: an open office space for Chinese start-ups**[155]
The Garage Cafe is a café in the Zhongguancun area that is more than a plain coffee place; it is turning out to be one of the go-to places for business capital. The café positions itself as an open office space for start-up companies. Two months after its opening, there have been over 30 venture capitals and angels who have come to this place in hopes of finding promising projects, including some top-notch players such as Matrix China, WI Harper, Shanda Capital and so on. Four teams have succeeded in securing funding here.

Interestingly, most high-tech firms of the Zhongguancun Science Park cluster have been organised under the "four self-principles" encouraged by the government. They are expected to have self-chosen partners, be self-financing, operate independently (i.e. independent decision making and managerial autonomy) and have self-responsibility for all losses incurred[156]. The ability to do so is greatly dependent on the ability to raise capital.

As for Taiwan, the availability of funds and capital has played an essential role for the cluster foundation and development. It has especially helped to strengthen the high-tech manufacturing industry. Moreover, it helped create a productive environment to facilitate the entry and growth of SMEs. This early-stage investment has also happened in the case of TSMC. *The development of the Taiwan's venture capital industry has reached a relatively high level, and nowadays it is the third most active venture capital market in the world, ranking just behind the US and Israel*[157].

The Taiwanese government initiated the Taiwanese venture capital industry in the early 1980s, inspired by the example of Silicon Valley. The Ministry of Finance in Taiwan established the institutional framework for the Taiwanese venture capital industry in order to provide financial support for research-intensive production. The whole establishment process has been coordinated and advised by professionals. Organised collaborations with large US banks to transfer financial and managerial expertise were created, and teams were sent to Silicon Valley to be trained in managing a venture capital firm. The government offered a 20% tax reduction to individual or corporate investors in venture capital funds that were targeted at strategic (technology-intensive) industries. Moreover, faced with the challenge of raising capital from Taiwan's risk-averse financial and industrial communities, the Taiwanese government invited overseas Chinese investors to establish venture firms in Taiwan[158].

The companies accommodated in the Hsinchu Science Park cluster have the opportunity to profit from a number of financing alternatives. Venture capital, governmental funds and investments, and financial resources from the side of the "reverse" brain drain[159] represent the financing alternatives

[155] New York Times, 2012. "SMIC secures USD 600 Million Syndicated Loan", retrieved from: http://markets.on.nytimes.com/research/stocks/news/press_release.asp?docTag=201203160719PR_NEWS_USPRX____CN71580&feedID=600&press_symbol=255887
[156] Tan, J. (2006). "Growth of Industry clusters and innovation: Lessons from Beijing Zhongguancun Science Park". Journal of Business Venturing, 21, 827-850.
[157] Sun et al. (2009): "The evaluation of cluster policy by fuzzy MCDM: Empirical evidence from HsinChu Science Park", Expert Systems with Applications, Taiwan
[158] Saxenian (2002): "Taiwan's Hsinchu region: imitator and partner for Silicon Valley", University of California at Berkeley, May 2002, Paper presented at the Conference on Clusters, Industrial Districts and Firms: the Challenge of Globalization
[159] Thousands of Chinese engineers who had been educated and had worked in the US, came back to Taiwan to either start up companies themselves or work for start-ups or already established companies. The returnees were responsible for the establishment of more than 40% of the 284 companies located in the Park in 1999. (from Saxenian (2002):

that have contributed to financing of the companies in the cluster. Additionally, the banking sector in Taiwan often offers syndicated loans, with several banks (numbering from four to ten) “teaming up” in order to be able to provide sufficient level of capital to these firms.

#### *3.1.5.5. Lessons for Europe*

The capital intensive nature of the semiconductor industry means that innovation and new products require massive investment in terms of manufacturing. On the flipside, the market is volatile and prices are often not realistic due to the competitive nature of the industry, with many companies resorting to selling below manufacturing cost. Consequently, it becomes difficult to make the decision to invest, given the uncertainty on the return on investment. As such, *a mechanism that stimulates syndicated lending under favourable conditions could ease this tension and contribute to the international competitiveness of European semiconductor companies.*

In Europe, the challenge related to VC funding is that most of the value is diluted substantially in the transaction, such that the value in the original research, development and innovation (R&D&I) invested by the EU or Member States into new technology development becomes diluted and subsequently owned by foreign investors who enter later in the process. As such, *while inward investment is good, equity and dilution rules should be carefully managed*.

Specifically, VC facilities managed by the European Investment Fund (EIF) should be significantly boosted. Entrepreneurship, which is often the final missing link between research outputs and realising commercial value, needs to be incorporated into the full innovation programme lifecycle. In Europe, there is a clear need for better integration and connectivity between research and innovation processes. Further, VC and growth capital sectors (rather than buy-out industry sectors) should be promoted, and the EU should incentivise the funding of these sectors. This can be done by increasing the allocation of these sectors in institutions such as EIF or European Investment Bank (EIB). Additionally, *the EU should promote the creation of a fund of funds that would act as a limited partner to funds operating in Europe*. This fund of funds would attract money from individuals and companies. The fund of funds would then allocate the funds throughout the continent based on commercial measures.

Finally, there is a need to improve general access to VC and finance and by SMEs in particular, through the easing or removal of barriers and restrictions to company growth.

### *3.1.6. Public-private partnerships*

Public-private partnerships (PPP) is a term describing different forms of cooperation and collaboration between public and private entities. These cooperative establishments are founded with the goal of creating certain services or projects. Such cooperation can be medium or long term in nature based on the contract between institutions from the public and private sectors.

“Taiwan's Hsinchu region: imitator and partner for Silicon Valley”, University of California at Berkeley, May 2002, Paper presented at the Conference on Clusters, Industrial Districts and Firms: the Challenge of Globalization)

#### *3.1.6.1. The importance of public-private partnerships for the semiconductor clusters*

Public-private partnerships are the driving force behind many semiconductor clusters. These partnerships create a platform for extensive knowledge sharing, innovative spin offs and leading-edge R&D.

Public-private partnerships help to expand the cluster and keep it competitive in several different ways. Firstly, collaboration in research and consultancy helps small companies to keep initial costs low and build a strong business case. Secondly, free provision of services like IP lawyers and accountants, by, for example, universities, also helps to keep costs for start-ups low. Thirdly, the incubation of start-ups and spinoffs helps start-ups build a strong business case in a protected environment. This business case can be built using the knowledge base at universities, IP licensing, and support in development of new products and services. Companies which have matured beyond the start-up phase can also continue to benefit from knowledge at research institutes through connections established between regional companies and knowledge bases present in higher educational communities[160].

Table 3-6 provides an overview of the key findings on public-private partnerships.

TABLE 3-6: Overview of key findings on policy measures and incentives: Public-private partnerships

| 1.6 Policy measures and incentives: Public-private partnerships | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | Public-private partnerships are often reported to be at the centre of the clusters' development in Europe.<br><br>Public-private partnership programmes focused on micro/nanoelectronics refer to ENIAC, FP7, EUREKA/CATRENE, and a number of national programmes. The characteristics of such public-private partnerships are the following:<br>• Intense collaboration between public and private sectors;<br>• A highly active role of the public sector;<br>• A strong entrepreneurship supported by investment funds of large industrial groups present at the local level; *and*<br>• An international scope, based on the collective dynamics of the system of actors. |
| Three key public-private partnerships in Grenoble include Crolles 3, Minatec and Minalogic. Another example is Alliance Crolles 2, which was the predecessor to Crolles 3. Additionally, cluster members play a prominent role in the European programmes CATRENE and ENIAC. The participation of France in these programmes is substantially higher than that of the other countries such as Germany. | |
| ***Silicon Saxony (Dresden, Germany)*** | |
| There are many PPPs in Silicon Saxony. Providing funding which is conditional on PPPs has allowed for emergence of the facilities such as Center Nanoelectronic Technologies (CNT) and NaMLab. Another example is the Advanced Mask Technology Center (AMTC). | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| One of the key initiatives is the "Knowledge and Innovation Community" (KIC). Other examples of public-private partnerships can be found on the "High-tech Campus" at Eindhoven. Here the TU/e (University of Eindhoven) collaborates closely with for instance Philips and ASML. Furthermore, KU Leuven and IMEC also closely collaborate with the private sector in the Belgian part of the cluster. | |
| ***Silicon South West (South West England, UK)*** | |
| Given the dominance of start-ups, public-private partnerships have no significant impact on the development of the cluster in comparison with, for instance, venture capital funding, entrepreneurial activity and the pool of knowledge workers. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | Dell, Intuit, Microsoft, and Intel |

[160] Marston L., Shanmugalingam S., and Westlake S. (2010) "Chips with everything: Lessons for effective government support for clusters from the South West semiconductors industry", NESTA, available at: http://www.nesta.org.uk/library/documents/Semiconductorsv10.pdf

| 1.6 Policy measures and incentives: Public-private partnerships | |
|---|---|
| No data was available on the current semiconductors-related public-private partnerships in Silicon Valley. | currently headline a group of Silicon Valley elite partnering with the Obama administration to create entrepreneurial clusters and aid start-up companies around the country. Fulfilling a relatively underserved market, they aim to provide free services and networking to entrepreneurs. |
| ***Tech Valley (Albany, US)*** | |
| Public-private partnerships are reported to drive the cluster. This factor is reported to have been crucial for IBM to stay in the region. Nowadays, around 250 people of GLOBALFOUNDRIES work together with people from IBM at CNSE. This partnership goes beyond CNSE, and involves joint development of IBM's 32nm Silicon-on-Insulator (SOI) technology and implementing this technology at GLOBALFOUNDRIES new fab in Saratoga Springs. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)*** | Asian countries recognise the importance of public-private partnerships for the international competitiveness.<br><br>While public-private partnerships are relatively new in China, it is suggested that there is great potential for their application due to the strong demand for public facilities and services.<br><br>The level of collaboration between industry and universities in Taiwan is relatively high, with Taiwan ranking seventh in the world in this dimension. |
| Most of the partnerships center around the two famous universities, the University of Peking and Tsinghua University. The driving force behind the cluster is a concentration of private high-tech companies which includes many start-ups spun off from universities and state-run research institutes. Some of these university spinoff companies have grown into the leading players of the Chinese high-tech industry. | |
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | |
| There are a few public-private partnerships present. Three key players comprising most of the collaborations with companies are the Industrial Technology Research Institute and two high-quality universities National Chiaotung and Tsing Hua University. | |

### *3.1.6.2. Public-private partnerships in Europe*

Public-private partnerships are often reported to be at the centre of the clusters' development in Europe. These imply strong investments into the infrastructure and are essential for meeting the needs of the clusters. The partnerships between the firms and research centres are essential for collaborative research, training initiatives and knowledge transfer within the cluster. The geographical proximity of different cluster actors also strengthens and encourages public-private partnerships and allows for easier collaboration. Moreover, more active collaboration between research institutions and SMEs benefits both sides. It allows public research bodies to ensure they secure the best possible economic benefits, while at the same time allowing SMEs to obtain the support they need to refine the technologies they develop[161].

In Europe, examples of public-private partnership programmes which are focused on micro/nanoelectronics include ENIAC, FP7, EUREKA/CATRENE, and a number of national programmes. The characteristics of such public-private partnerships are the following:

- Intense collaboration between public and private sectors;
- A highly active role of the public sector;
- A strong entrepreneurship supported by investment funds of large industrial groups present at the local level; *and*

[161] OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development

- An international scope, based on the collective dynamics of the system of actors[162].

When analysing the specific clusters, the following observations can be made. In Grenoble, three key public-private partnerships include Crolles 3, Minatec and Minalogic. Another example is Alliance Crolles 2, which existed a few years ago and was the predecessor to Crolles 3. Additionally, cluster members play a prominent role in the European programmes CATRENE and ENIAC. The participation of France in these programmes is substantially higher than that of other countries such as Germany[163].

In Silicon Saxony, one can find many forms of public-private partnerships, which have allowed for emergence of facilities such as Center Nanoelectronic Technologies (CNT) and Nano-electronic Materials Laboratory (NaMLab)[164]. Public-private partnerships and cooperation lie at the core of the cluster's competitiveness and as such play an essential role. These have attracted global players such as GLOBALFOUNDRIES, Infineon, Siltronic and SolarWorld, which have settled down in the cluster to profit from the beneficial environment and broad networks.

As for the DSP Valley and Eindhoven ASML cluster region, one of the key initiatives is the "Knowledge and Innovation Community" (KIC). KICs are highly integrated public-private networks of universities, research organisations and businesses aimed at strengthening the cluster and tapping into future financial resources[165]. KICs are European-level initiatives and represent legally and financially structured entities of internationally distributed but thematically convergent partners[166]. Other examples of public-private partnerships can be found on the "High-tech Campus" at Eindhoven. Here the TU/e (University of Eindhoven) collaborates closely with for instance Philips and ASML. Furthermore, the K.U. Leuven and IMEC also closely collaborate with the private sector in the Belgian part of the cluster, through the incubation of start-ups and licensing of process steps, modules, and even complete process technologies and IP blocks to companies in order for technology transfer to take place. Most of these public-private partnerships are a result of the various initiatives aimed at technology transfer, such as "Special Interest Groups", "Leuven Research & Development" and "Technology Transfer Cells".

In the Silicon South West cluster, given the dominance of start-ups, public-private partnerships have no significant impact on the development of the cluster in comparison to, for instance, venture capital funding, entrepreneurial activity, and the pool of knowledge workers.

***Key barriers and challenges***

The following key barriers and challenges were identified. The amount of capital invested by government into nanoelectronics is regarded to be too low, and government expenditures are

[162] "Competitiveness poles and public-private partnerships for innovation", Technopolis Group, 2010, available at http://www.technopolis-group.com/resources/downloads/101026_Competitiveness_poles_for_OECD.pdf

[163] "Wettbewerbsfähigkeit der europäischen Wirtschaft im Hinblick auf die EU-Beihilfepolitik – am Beispiel der Nanoelektronik", Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag , Juli 2010, Arbeitsbericht Nr. 137

[164] "Wettbewerbsfähigkeit der europäischen Wirtschaft im Hinblick auf die EU-Beihilfepolitik – am Beispiel der Nanoelektronik", Buro fur Technikfolgen-Abschatzung beim deutschem Bundestag, Juli 2010.

[165] "Engineering the Future, expanding the innovation ecosystem; talent, knowledge and connectivity", ELAt & Brainport Operations B.V., 2008

[166] http://eit.europa.eu/kics/

stagnating. Important development programmes that support the creation of new products and processes which can be used nationally have been reduced in number.

Another challenge refers to funding distribution related to cross-border cooperation. In particular, the "topping up" principle that the European Commission uses to divide the funding among Member countries within the joined technology initiatives (ENIAC and ARTEMIS) is reported to pose a barrier. This principle requires that European funding be divided based on the national funding budgets. It implies that small countries are by default disadvantaged as opposed to bigger countries, since they have smaller budgets to invest in these projects. European funding therefore tends to flow to bigger countries, which results in big countries being able to reinforce their national programmes, while smaller countries are forced to collaborate with non-European countries.

One more challenge concerns the strict IP rules which are applied by, for instance, most universities. This means that even though semiconductor companies are conducting bilateral partnerships with research organisations, the same research organisations tend to demand full ownership of potentially developed new technology and knowledge despite getting paid substantially for their cooperation. Merging the interests of commercial organisations with those of public ones is often difficult.

#### ***3.1.6.3. Public-private partnerships in the United States***

In the US, Dell, Intuit, Microsoft, and Intel currently headline a group of Silicon Valley elite which is partnering with the Obama administration to create entrepreneurial clusters and aid start-up companies around the country. By filling a gap in a relatively underserved market, they aim to provide free services and networking to entrepreneurs.

One of the world's most famous public-private partnerships in the field of semiconductors was established in 1987, when 14 highly competitive domestic semiconductor manufacturers, together with the federal government, formed a consortium called *Sematech* (Semiconductor MAnufacturing TECHnology). The new partnership was created as an experimental effort to regain the US share of the global microchip market and increase domestic semiconductor manufacturing expertise[167]. Sematech is currently headquartered in Albany.

Several other examples of public-private partnerships were identified[168]:

- State funding of 85 million USD for a public-private sector investment of 185 million USD to create the Albany Center of Excellence in Nanoelectronics;
- The commitment of over 160 million USD in state funding for the creation of International SEMATECH North (ISMTN), a five-year, 350 million USD programme in partnership with industry leaders to accelerate the development of next generation lithography, located at the Albany Center of Excellence;

[167] Longview Institute, "The Birth of the Microchip," http://www.longviewinstitute.org/projects/marketfundamentalism/microchip

[168] Semiconductor Industry Association (2003). "NY Governor George E. Pataki to Receive 2003 Noyce Award from Semiconductor Industry Association", available at http://www.sia-online.org/news/2003/11/02/news-2003/ny-governor-george-e.-pataki-to-receive-2003-noyce-award-from-semiconductor-industry-association

- A commitment of 100 million USD to support a 300 million USD research effort with Tokyo Electron Limited (TEL) focused on semiconductor tool development and deployment, also to be located at the Albany Center of Excellence; *and*

- A 400 million USD commitment by the New York government to support the Global 450mm Consortium's initiative at the University of Albany (UAlbany). The public-private partnership between the Global 450mm Consortium and the College of Nanoscale Science and Engineering (CNSE) at UAlbany aims to develop the 450mm manufacturing technology.

No data was available on semiconductor-related public-private partnerships in Silicon Valley. As for Tech Valley, public-private partnerships are reported to drive the cluster. This factor is reported to have been crucial for IBM to stay in the region. Nowadays, around 250 people of GLOBALFOUNDRIES work together with people from IBM at CNSE. This partnership goes beyond CNSE, and involves joint development of IBM's 32nm Silicon-on-Insulator (SOI) technology and implementing this technology at GLOBALFOUNDRIES new fab in Saratoga Springs[169].

#### *3.1.6.4. Public-private partnerships in Asia*

Asian countries recognise the importance of public-private partnerships for international competitiveness.

While public-private partnerships are relatively new in China, there is suggested to be a great potential for their application due to the strong demand for public facilities and services. Since 2000, public-private partnerships have become one of the government's strategies for the provision of public facilities and services. As this measure is relatively new to government officials, private investors and consumers, there is an apparent lack of experience on the commercial, technical, legal and political aspects of such initiatives[170].

In the Beijing cluster, there are reported to be a number of public-private partnerships. Most of these partnerships center around the two famous universities, the University of Peking and Tsinghua University. The driving force behind the cluster is a concentration of private high-tech companies which includes many start-ups spun off from universities and state-run research institutes. Some of these university spinoff companies have grown into leading players of the Chinese high-tech industry.

In Taiwan, companies in the semiconductor industry are viewed as competitors and usually do not cooperate with each other. However, training for the semiconductor industry is provided in the cluster, in which these companies take part together. The semiconductor industry also often recruits engineers from other companies. Most of the collaboration that does take place is through the Industrial Technology Research Institute (ITRI) and through universities.

Although there are only few public-private partnerships present at Hsinchu Science Park, these collaborative interactions help the cluster to meet the industry demand. In particular, the network,

[169] http://www.globalfoundries.com/newsroom/2012/20120109.aspx

[170] Ho P. (2006) "Development of Public Private Partnerships (PPPs) in China", Surveyors Times, Vol. 15, No. 10, October 2006, the Hong Kong Institute of Surveyors, available at http://www.icoste.org/Roundup1206/HoPaper.pdf

cooperation and collaboration among different actors are essential for the semiconductor industry in the cluster.

The level of the collaboration between industry and universities in Taiwan is relatively high. Taiwan is ranked seventh in the world in this dimension. Lately, however, challenges such as a lack of resources (i.e. engineers for the semiconductor industry) and a fall in the number of patents have been identified, which illustrates the need for increased collaboration between the three groups (government, private sector and universities) in order for the industry to develop and remain competitive[171].

#### *3.1.6.5. Lessons for Europe*

Public-private partnerships help to expand the cluster and keep it competitive by:

- Keeping the costs of R&D competitive;
- Generating knowledge and innovative technologies through collaboration between industry and academia;
- Creating jobs and spinoffs in the cluster region;
- Providing research organisations and universities with feedback from industry on the applicability of their research efforts;
- Enabling SMEs to participate in (European) public tenders, under the guidance of universities and research organisations; *and*
- Enabling "first of a kind product development", which requires many parties to collaborate (especially important for clusters with many small highly specialised companies).

Therefore, the strengthening of public-private partnerships in Europe is suggested to be a core priority of research and innovation policies. Several points for improvement were reported. Firstly, there is a need to advance the rules applicable to the consortia agreements (including the IP rules). Secondly, it is crucial to ensure that such partnerships are driven by the industry not research organisations. At the same time, there is a need to make sure that universities and research institutes are willing to collaborate and follow the needs of the industry. It is crucial for Europe to bring the results of its research efforts to industrialisation and to the market, and public-private partnerships can enable the region to move in this direction.

### *3.1.7. Other means*

The abovementioned policy measures and incentives are by far not the only factors influencing the decisions of semiconductor companies. When deciding where to locate a new plant, companies take into account issues such as the availability of highly skilled labour, the presence of other companies in the area, and so on.

[171] Chew et al. (2007): "Taiwan: Semiconductor Cluster", Harvard Business School, Massachusetts, US

### 3.1.7.1. *The importance of other means for the semiconductor clusters*

The impact of other policy measures and incentives on the competitiveness of clusters should not be underestimated. Even though some of the policies likely have a bigger impact on the competitiveness of the cluster than others, labour mobility stands out.

Table 3-7 provides an overview of the key findings on other means.

TABLE 3-7: Overview of key findings on policy measures and incentives: Other means

| **1.7 Policy measures and incentives: Other means** | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | The measures aimed at enhancing the semiconductor workforce in the cluster are suggested to be particularly important relative to other influential factors. This is because these measures aim to tackle the significant trend of a brain drain of technical talent due to the combined influence of an ageing population and the fact that less children are choosing to pursue technical education and careers. |
| Another factor behind the positive development of the Grenoble cluster lies in its ability to attract internationally renowned scientists.<br>A number of barriers and challenges can be identified:<br>• The scale and quality of public infrastructure;<br>• High prices of land and property in Grenoble and surrounding areas; *and*<br>• Opposition of some groups to the development of the cluster. | |
| ***Silicon Saxony (Dresden, Germany)*** | |
| The cluster is further impacted by the following policy measures:<br>• Advancing environmental initiatives and trade liberalisation;<br>• IP Regulation;<br>• Harmonisation of ICT standards and standardisation processes; *and*<br>• Labour mobility. | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| The cluster is influenced by the following measures:<br>• Single market regulation facilitated the expansion of the cluster from Leuven to the Eindhoven region and was enabled by Interreg 3A-funding;<br>• Enhancing semiconductor workforce, which is enabled through the BRAINS policy/project;<br>• Advancing trade liberalisation within a European context;<br>• Developing cross-border activities, linking up and exchanging information with partner organisations across the border and supporting this with various 'infostructure' services; *and*<br>• Movement towards smart specialisation, which is aimed at developing a stronger differentiation between the various European clusters. | |
| ***Silicon South West (South West England, UK)*** | |
| A key policy measure affecting the cluster is the enhancement of the semiconductor workforce. The UK Electronics Skills Foundation was thus launched to improve the quality and quantity of employment-ready graduates. Further, restrictive migration laws post a real problem to the design-focused cluster, as, of all value chain activities, design requires the highest level of engineering talent which may only be sourced outside of Europe. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | The supply of Americans graduating with degrees in science, technology, engineering and mathematics (STEM) will not be able to meet the demands of a post-recovery US economy. Meanwhile, current US immigration policies prevent American companies from retaining or recruiting the world's best innovators – including many who |
| One of the key success factors of the cluster is reported to be its people, who come from both around the country and around the world. In particular, immigrant entrepreneurs have contributed considerably to innovation and job creation in the region. Traditionally, Silicon Valley's universities have served as the primary port of entry of foreign talent. Maintaining and increasing this flow has vastly improved its global competitiveness. However, a key policy measure influencing this development relates to the US immigration policy which is not seen as favourable for such developments. | |

| 1.7 Policy measures and incentives: Other means | |
|---|---|
| ***Tech Valley (Albany, US)*** | have been educated at US universities. |
| As both GLOBALFOUNDRIES and IBM have a production facility in Tech Valley, it is important to enhance the educated semiconductor workforce. Hudson Valley Community College offers an educational programme specifically for this. Students enrolled in the programme receive highly specialised training in semiconductor and nanotechnology, digital electronics, electro-mechanical devices, semiconductor manufacturing and nanofabrication processes. The curriculum consists of seven courses to be completed over two semesters. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)*** | Asian clusters are reported to benefit from an opposite trend, a so-called 'reverse' brain drain, which implies that thousands of Chinese engineers who have previously studied and/or worked in the US have subsequently returned to China or Taiwan to either start companies themselves or work for start-ups or already established companies. |
| To facilitate overseas returnees, in Beijing, there are 29 overseas student pioneer parks. To attract more overseas talent, the Zhongguancun Administration Committee has also established liaison offices in Silicon Valley in California, Washington D.C., Toronto, Tokyo, Munich and Hong Kong. In total there are more than 15,000 overseas returnees in Zhongguancun, who have established more than 6,000 enterprises in the park. | |
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | |
| In Hsinchu Science Park, the returnees were responsible for the establishment of more than 40% of the 284 companies located in the Park in 1999. | |

### *3.1.7.2. Other means in Europe*

The measures aimed at enhancing the semiconductor workforce in the cluster are suggested to be particularly important relative to other influential factors. This is because these measures aim to tackle the significant trend of a brain drain of technical talent due to the combined influence of an ageing population and the fact that less children are choosing to pursue technical education and careers[172]. This is a field where public policy is suggested to fall short and where industry needs to step in in order to make an impact. Measures aimed at tackling the problem of a decreasing quality and quantity of engineering talent in the cluster region also partially solve other issues such as the lack of venture funding and growth capital and the retention of multinationals in the region.

Labour mobility is one of the key factors to successful innovation, since it helps to spread knowledge and technologies[173]. A highly skilled, highly educated workforce is central to the cluster's ability to maintain its innovation leadership. The Grenoble cluster is suggested to be able to attract internationally renowned scientists. For example, the cluster is home to Professor Louis Néel, the winner of the Nobel Prize for Physics in 1970. The cluster also attracts highly skilled workers and enthusiastic entrepreneurs[174].

**Knowledgeable and highly skilled migrants in France**

In order to increase migration to France of skilled immigrants, the French Parliament voted for the creation of the Skills and Talents Card (*Carte Compétences et Talents*) in May 2006. This card is valid for three years and renewable, aimed to facilitate the welcome of foreigners "whose personalities and talents constitute assets for the development and the influence of France". It allows the immigrant to work in France and to obtain temporary residence cards 'Private and family life' (*Carte Vie Privée et* Familiale)[175].

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[172] OECD (2008) "Encouraging Student Interest in Science and Technology Studies", Global Science Forum, Chapter 1 "Quantitative Analysis: Is There a Real Decline?"

[173] OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development

[174] OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development

[175] http://www.takingupresidence.com/france/visas-permits/knowledgeable-and-highly-skilled-migrants.10.html

Skills and Talents Card: eligibility criteria

The following type of persons may be eligible for the Skills and Talents Card:

- University graduates;
- Qualified professionals with a minimum of three to five years of professional experience in the field they apply for the visa, regardless of their level of education;
- Investors in an economic project (minimum investment of 300,000 EUR or proof of capacity to create a minimum of two sustainable jobs in France, not including the one held by the applicant or his family);
- Independent professionals such as artists, authors etc.; *and*
- Senior manager and high level executives employed by a French company.

Labour mobility was also mentioned as a challenge in Dresden and Silicon South West. The latter reported that the pool of graduate electronic engineers continues to shrink. Training is costly and too few companies are able to fund it, creating an ever growing skills gap. The UK Electronics Skills Foundation was launched to improve the quantity and quality of employment-ready graduates[176]. More investment in skills and engineering capabilities is however needed. Examples of possible investments are companies financing courses at schools and the subsidisation of master programmes.

Furthermore, the latest immigration laws in the UK pose a particular challenge for the British semiconductor industry, as they significantly restrict companies from hiring employees from outside the European Union. When the skills required by industry are not readily available within the EU, the simplest solution to address this lack of skills is by hiring from outside the EU. When it comes to the semiconductor industry, of all activities along the value chain, design requires the highest level of engineering talent and therefore has a higher need for hiring non-European employees. Once a manufacturing facility is in place, relatively little engineering talent is needed. Accordingly, the restrictive migration law poses a significant problem for semiconductor design activities, which are most prevalent in the Silicon South West cluster.

#### *3.1.7.3. Other means in the United States*

As is the case with Europe, one of the suggested key factors driving the success of the semiconductor clusters in the US is related to the presence of a highly skilled and highly educated workforce. The latter represents a big challenge for this region. The supply of Americans graduating with degrees in science, technology, engineering and mathematics (STEM) is not expected to meet the demands of a post-recovery US economy. Meanwhile, current US immigration policies prevent American companies from retaining or recruiting the world's best innovators – including many who have been educated at US universities[177]. Therefore, if current immigration measures do not change, US' economic leadership could be significantly weakened.

**America's Immigration System: A Competitive Disadvantage[178]**

Congress has failed to reform the employment-based (EB) green card and H-1B visa systems that US employers use to recruit and retain top worldwide talent. The broken green card system causes employees to spend years in limbo, unable to be promoted or relocated without restarting the process. Over 3,700 H-1Bs in the semiconductor industry seek permanent resident status, and over 500 applicants have been waiting for 4 years or more. The result is that America is less welcoming to the world's best and brightest at a time when other countries are increasing their efforts to attract these individuals.

[176] http://www.ukesf.org/summer-schools

[177] http://www.sia-online.org/public-policy/environment-safety-health/

[178] http://www.sia-online.org/public-policy/workforce/

More than half a million doctors, scientists, researchers, and engineers in the US are on temporary work visas and are waiting for permanent-resident visas, which are in extremely short supply (85,000 visas are granted per year). These workers cannot start companies or justify buying houses. They could be required to leave the US immediately and without notice if their employer lays them off. As a result, many of them choose to return home[179].

For foreign entrepreneurs wishing to implement their plans to start up a company in the US, there is a strong risk of being denied a visa, due to a very narrow view of what a start-up company should look like. There are multiple examples of immigrant founders who have run into problems in obtaining visas, even though many of them have been funded by venture capitalists or had definite plans with other professionals to start companies. In some cases, visas have been denied despite the company having been funded, because the start-up could not demonstrate a viable revenue stream yet[180].

In the case of Silicon Valley, one of the key success factors is reported to be its people, who come both from around the country and around the world. In particular, immigrant entrepreneurs have contributed considerably to innovation and job creation in the region[181]. Between 1995 and 2005, 25% of start-ups in Silicon Valley had at least one immigrant founder. These start-ups created more than 450,000 jobs[182].

Traditionally, Silicon Valley's universities have served as the primary port of entry of foreign talent. Maintaining and increasing this flow has vastly improved its global competitiveness[183]. However, as mentioned above, a key policy measure influencing this development refers to the US immigration policy which is currently viewed as not being favourable for such developments.

**Hudson Valley Community College's Semiconductor Manufacturing Technology programme (SMT programme)[184]**

The SMT programme, developed in partnership with CNSE, prepares students for careers in the semiconductor manufacturing industry. The training provided is field-oriented and generally covers the principles and practices that apply to industry applications of electricity and semiconductor manufacturing. Upon graduation, students will be prepared to work in capacity field service, test, and manufacturing, or may transfer to a baccalaureate programme.

Similarly, skilled people are crucial for Tech Valley. As both GLOBALFOUNDRIES and IBM have production facilities in Tech Valley, it is important to enhance the educated semiconductor workforce. Hudson Valley Community College offers an educational programme specifically for this. Students enrolled in the programme receive highly specialised training in semiconductor and nanotechnology, digital electronics, electro-mechanical devices, semiconductor manufacturing and

179 http://techcrunch.com/2011/03/06/why-silicon-valley-immigrant-entrepreneurs-are-returning-home/
180 http://techpresident.com/news/21808/obama-administration-lands-silicon-valley-ask-how-it-can-improve-immigration-process
181 Saxenian A. (2002) Local and Global Networks of Immigrant Professionals in Silicon Valley. San Francisco: Public Policy Institute of California. See also, Anderson S. & Platzer M. (2006) "American Made. The Impact of Immigrant Entrepreneurs
and Professionals on U.S Competitiveness", National Venture Capital Association
182 http://techcrunch.com/2011/03/06/why-silicon-valley-immigrant-entrepreneurs-are-returning-home/
183 Silicon Valley Index 2012
184 http://www.albany.edu/outreach/SMT_program.php

the nanofabrication processes. The curriculum consists of seven courses to be completed over two semesters[185].

#### 3.1.7.4. *Other means in Asia*

Asian clusters are reported to benefit from an opposite trend, a so-called ‘reverse’ brain drain, which implies thousands of Chinese engineers who have previously studied and/or worked in the US have subsequently returned to China or Taiwan to either start companies themselves or work for start-ups or already established companies. Not only does this enable technology transfer from developed countries, it has also resulted in the formation of many new companies.

To facilitate overseas returnees, in Beijing, there are 29 overseas student pioneer parks. To attract more overseas talent, the Zhongguancun Administration Committee has also established liaison offices in Silicon Valley in California, Washington DC, Toronto, Tokyo, Munich and Hong Kong. In total there are more than 15,000 overseas returnees in Zhongguancun, who have established more than 6,000 enterprises in the park[186].

In Hsinchu Science Park, the returnees were responsible for the establishment of more than 40% of the 284 companies located in the Park in 1999[187].

#### 3.1.7.5. *Lessons for Europe*

To enhance the semiconductor workforce, the need to focus on *the development of the European workforce* as opposed to relying on non-EU workers was expressed. This can be achieved through developing a strong European educational system that provides a consistent stream of well educated, talented engineers for the high-tech industry. We will elaborate on this aspect in Chapter 4 of this Report.

## 3.2. *R&D&I capacities*

This section compares the R&D&I capacities across the analysed clusters. As described in *Chapter 2*, R&D&I capacities include a wide range of factors. These include:

- The presence of regional integrated expert centres, technology-transfer centres and innovation centres forming regional intellectual and R&D&I bases;
- The availability of innovation services, SME consultancy, education and training;
- The presence of large companies; *and*
- The presence of a strong innovative SME base.

[185] https://www.hvcc.edu/catalog/programs/eit/smc.html
[186] http://en.zgc.gov.cn/2011-12/16/content_14089530.htm
[187] Saxenian (2002): “Taiwan's Hsinchu region: imitator and partner for Silicon Valley”, University of California at Berkeley, May 2002, Paper presented at the Conference on Clusters, Industrial Districts and Firms: the Challenge of Globalization

#### *3.2.1.1. The importance of R&D&I capacities for the semiconductor clusters*

For the semiconductor industry, R&D is one of the main factors driving competitiveness. High R&D intensity of the industry requires the presence of prominent universities and research centres in the cluster. Micro- and nanoelectronics build on research in many fields, ranging from physics through mechanics to computing and the study of components and materials. Moreover, R&D is fundamental to the highly innovative sector. Research institutions and universities all over the world have played a pivotal role in the development of clusters, especially through spin-offs of newly developed technology.

Table 3-8 provides an overview of the key findings for this dimension.

TABLE 3-8: Overview of key findings on R&D&I capacities

<table>
<tr><th colspan="2">2 R&D&I capacities</th></tr>
<tr><td>EUROPEAN CLUSTERS</td><td></td></tr>
<tr><td>Individual descriptions</td><td>Commonalities</td></tr>
<tr><td>Grenoble (Grenoble, France)</td><td rowspan="6">Current R&D&I capacities<br>One of the major strengths of the clusters is the presence and high density of research institutions within the radius of universities and research centres. Thanks to these capacities, the public sector in the clusters can provide sufficient basis for private sector projects looking for the development of practical applications.<br><br>Necessary improvements<br>It was suggested that the salaries in the public research sector need to be made more attractive to ensure ample supply of highly skilled researchers and technicians in the clusters.<br><br>Furthermore, attracting and retaining excellent human capital is a key focus area. While it is not a necessary condition for all clusters, for several it was suggested that there needs to be a higher inflow of such human capital.<br><br>Job mobility, especially within Europe, could be further improved. It was confirmed in other clusters that human capital tended to stay in the area they were living in.</td></tr>
<tr><td>2.1 Current R&D&I capacities<br>Public R&D&I capacities in micro- and nanoelectronics are concentrated in the world famous laboratories such as CEA-Leti, enabling Grenoble-Isere to rank among the top French departments for the registration of electronics patents. Private research relies on considerable human resources and capital in key projects such as the STMicroelectronics-IBM Alliance.<br><br>2.2 Necessary improvements<br>First, the salaries in the public research sector need to be made more attractive to ensure there are enough researchers and technicians in universities and public research centres. The programmes offered by universities should be adapted to the needs of the cluster. The level of supply of the risk capital should also be raised in order to support the creation and development of innovative SMEs.</td></tr>
<tr><td>Silicon Saxony (Dresden, Germany)</td></tr>
<tr><td>2.1 Current R&D&I capacities<br>The cluster is home to regional integrated expert centres, technology-transfer centres and innovation centres forming regional intellectual and R&D&I bases, as well as 1,500 IT companies, 200 companies (whole value chain of traditional microelectronics), 14 Fraunhofer institutes, 5 universities of applied science, 4 Leibnitz institutes, 7 universities, 2 Max-Planck institutes (Network Thinking), as well as innovation services, SME consultancy, education and training.<br><br>2.2 Necessary improvements<br>While there are excellent engineering studies in and around Dresden, a deepened focus on these areas may bring about an increasing inflow of excellent human capital. This in turn would strengthen the competitiveness of the region.</td></tr>
<tr><td>DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)</td></tr>
<tr><td>2.1 Current R&D&I capacities<br>The cluster has a strong base of R&D&I capacities. The cluster is formed around two technical universities (Eindhoven and Leuven) and is home to strong international companies, such as ASML and Philips, as well as a leading research institution in the field of micro engineering (IMEC). The region also boasts of a strong SME base.<br><br>2.2 Necessary improvements<br>It was noted that more cross-border and international cooperation is needed to create critical mass, diversify the technology base, raise global competitiveness and attract more direct investment. Attracting high-level researchers and knowledge workers to improve the regional workforce was also considered of key importance. Finally,</td></tr>
</table>

| 2 R&D&I capacities | |
|---|---|
| dovetailing national innovation programmes with resources may create more flexibility within the cross-borders toolbox. Further alignment of national resources generates greater possibilities in terms of capacity and volume. | |
| ***Silicon South West (South West England, UK)*** | |
| **2.1 Current R&D&I capacities**<br>The region has a high concentration of semiconductor design companies, with more designers located in South West England than anywhere in the world excluding the US, and it has 50% more designers than the next largest cluster of designers, Cambridge. Job mobility is also a key attribute of the SSW cluster, which creates greater innovation and enhances the attractiveness of the cluster as a whole. The cluster is also noted for a strong innovative SME base, and is said to host “perhaps the most vibrant semiconductor start-up community in the world”. Further, the presence of semiconductor serial entrepreneurs, which has contributed to economic activity in the region, and far sighted universities actively involved in the cluster’s development, are other factors contributing to the cluster’s R&D&I capacities.<br><br>**2.2 Necessary improvements**<br>Two adjustments which are particularly important for SSW are:<br>• Support to industry-led intermediaries, such as a trade organisation, which could support cluster development in several ways; *and*<br>• Even greater job mobility, which would further stimulate growth of the cluster.<br>Further, a more assertive policy of the European bank to co-fund UK venture funds such that most of the money is put into early-stage companies, and the engagement of pan-European syndication of venture capital investments to stimulate cross-cluster trading and connect clusters across the value stream, would prove beneficial. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| Individual descriptions | Commonalities |
| ***Silicon Valley (San Francisco Bay Area, US)*** | **Current R&D&I capacities**<br>**World-class R&D centers** are located in the region as well **as top universities in the field**. These institutions play a pivotal role in the development of the cluster.<br><br>**Necessary improvements**<br>Current US **immigration policy needs to be changed** as it represents a highly unfavourable framework condition for attracting and keeping talented researchers and engineers. |
| **2.1 Current R&D&I capacities**<br>A great deal of Silicon Valley’s success can be traced back to the founding of Stanford University. There are currently several other colleges and universities which add to the R&D&I pool such as Hayward State University, San Jose State University, UC Berkeley, UC San Francisco, etc. There are also several world-class R&D centres such as Center for Information Technology Research in the Interest of Society (CITRIS), NASA Ames Research Center, and Molecular Foundry (a national user facility that will provide researchers and Bay Area companies with the cutting-edge tools they need to explore the frontiers of nanotechnology).<br><br>**2.2 Necessary improvements**<br>The Stanford School of Engineering, typically rated first or near first in the US, regularly provides the region with a highly skilled labour force and attracts top researchers from around the US and the world. However, the current immigration policies for potential entrepreneurs are reported to represent a highly unfavourable framework condition. | |
| ***Tech Valley (Albany, US)*** | |
| **2.1 Current R&D&I capacities**<br>Tech Valley is home to excellent R&D facilities. The excellent CNSE research centre is one of the leading institutions in micro and nano engineering research. The research is supported both with government funds as well as by private investments from leading semiconductor companies (for example, Intel, IBM, GLOBALFOUNDRIES, SEMATECH, ASML). Moreover, the Hudson Valley Community College and UAlbany offer highly specialised education in the relevant fields.<br><br>**2.2 Necessary improvements**<br>Despite a strong R&D base, the current immigration policies for potential entrepreneurs are reported to represent a highly unfavourable framework condition. Moreover, SIA is calling for permanent R&D tax credits, which may boost the R&D&I capacities of the cluster. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |

<table>
<tr><th colspan="2">2 R&D&I capacities</th></tr>
<tr><th>Individual descriptions</th><th>Commonalities</th></tr>
<tr><td>Zhongguancun (Beijing, China)</td><td rowspan="4">Current R&D&I capacities<br>While the Asian clusters have access to top universities and research centres, their share in semiconductor R&D and design is comparatively low. However, there is a strong basis for R&D and with the various institutions and universities in place, we can expect the region to become a bigger force in this area.<br><br>Furthermore, the availability of high-quality human capital is of key importance. Both clusters were found to encourage students/engineers/researchers to hold a position abroad for some years, and return with the newly gained knowledge.<br><br>Necessary improvements<br>There is a need for a shift towards more R&D-based activities. Linkages between R&D organisations, academia and industry need to be encouraged, and high-tech spin-offs from R&D organisations need to be further stimulated.</td></tr>
<tr><td>2.1 Current R&D&I capacities<br>The Zhongguancun Science Park is one of the regions with the most intensive talent and educational resources in China. The educational resources in the park include 32 higher educational institutions, including Peking University and Tsinghua University, and 206 national and regional research institutions. Members of the Chinese Academy of Science and the Chinese Academy of Engineering working in the park account for 36% of the nation's total. The “One Thousand Talents Programme”, which aims to stimulate talent in the nation, consists of 418 talented working staff members from Beijing, of which Zhongguancun has 80%. Furthermore, there are more than 15,000 overseas returnees in Zhongguancun, who have in turn established more than 6,000 enterprises in the park. As a result, Zhongguancun has become a region with the most enterprises founded by overseas returnees in China.<br><br>2.2 Necessary improvements<br>There is a strong need to establish a system and a mechanism that is in favour of independent innovations and, more importantly, that enhances the indigenous innovation ability. The current FYP (2011-2015) puts a strong focus on making a shift to more R&D-based activities. This is needed to improve the overall competitiveness of the domestic semiconductor industry. The cluster organisation has also identified this need and aims to actively support the transition.</td></tr>
<tr><td>Hsinchu Science and Industrial Park (Hsinchu, Taiwan)</td></tr>
<tr><td>2.1 Current R&D&I capacities<br>HSP is located near two prestigious technical universities, National Chiao Tung University and National Tsing Hua University, and two major research institutions, the Industrial Technology Research Institute (ITRI) and the Food Industrial Research and Development Institute (FIRDI). ITRI has played an essential role in the growth of Taiwan’s SMEs via spin-offs or technology transfer, while FIRDI employs around 300 researchers focusing on food development and biotechnology. In essence, the availability of high-quality human resources is the key driving force for the cluster. HSP also has a strong innovative SME base, thanks to the Taiwanese innovation system’s high focus on SMEs.<br><br>2.2 Necessary improvements<br>Three key elements are identified as potential avenues for boosting R&D&I capacities:<ul><li>Encouraging linkages between R&D organisations, academia and industry;</li><li>High-tech spin-offs from R&D organisations (for example, ITRI) to companies; and</li><li>Technology transfer from technology-leading countries.</li></ul>There is also a call for more active support from the government in developing new manufacturing technology, which is highly capital intensive.</td></tr>
</table>

### *3.2.1.2. R&D&I capacities in Europe*

Compared with their main counterparts, EU companies present a weak position in terms of growth and number or weight of companies, with the US dominating in terms of number of companies and total R&D investment in the sector[188]. Europe is in general an attractive area for R&D. The engineering cost of Europe is competitive compared with other regions, even to the Asian ones. When comparing the total numbers of researchers per region, Europe comes second just after the US[189].

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188 2010 EU Industrial R&D Investment Scoreboard

189 “Vision, mission and strategy: R&D in European Micro- and Nanoelectronics”, AENEAS report at http://www.aeneas-office.eu/web/downloads/aeneas/vms_final_feb2011_1.pdf

In Europe, public R&D&I capacities in micro- and nanoelectronics are concentrated in world famous laboratories such as CEA-Leti (Grenoble) and IMEC (Eindhoven/Leuven). These world class institutions enable regions such as Grenoble-Isere to rank among the top French regions for the registration of electronics patents. Private research relies on considerable human resources and capital in key projects, such as the STMicroelectronics-IBM Alliance in Grenoble. IMEC in particular was identified by stakeholders outside Europe as one of the leading research institutions in the field, underlining the strong capabilities of Europe.

Another important factor that drives the clusters in Europe is a strong SME base. Silicon South West, for example, is said to host "*perhaps the most vibrant semiconductor start-up community in the world*". Furthermore, the presence of semiconductor serial entrepreneurs there, which has contributed to economic activity in the region, and far sighted universities actively involved in the cluster's development, are other factors contributing to the cluster's R&D&I capacities.

***Key barriers and challenges***

Some of the key challenges for the innovation-related activities are reported to be as follows: the uncertainty of demand, insufficient financing, the cost of innovation and the difficulties in establishing partnerships. Additionally, customer-oriented communication is needed to inform and teach customers and the broader publics about the innovations and thereby positively impact the demand side[190].

Furthermore, for one of the clusters (Grenoble), it was stressed that the salaries in the public research sector need to be made more attractive to ensure there are enough researchers and technicians in universities and public research centres. In more cases, it was also said that increasing the intensity of vocational and technical training was essential. The programmes offered by universities should be adapted to the needs of the cluster to foster highly-skilled human capital. Furthermore, it is important to facilitate the mobility of the research staff and offer research exchange programmes so that through labour mobility the R&D&I can profit from synergies of different research centres. Additionally, various types of funding for research projects, SMEs, public and private research institutes should be provided at sufficient and motivating levels. The level of supply of the risk capital should also be raised in order to support the creation and development of innovative SMEs[191].

#### ***3.2.1.3. R&D&I capacities in the United States***

High R&D intensity of the industry requires the presence of prominent universities and research centres in the cluster. In case of Silicon Valley, the Stanford School of Engineering, typically rated first or near first in the US, regularly provides the region with a highly skilled labour force and attracts top researchers from around the US and the world. In Tech Valley, the UAlbany and its NanoTech Complex play a pivotal role in the development of the cluster. Moreover, Hudson Valley Community College offers a highly specialised programme for semiconductor manufacturing.

190 OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development
191 OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development

Although the US boosts an impressive R&D&I base, the region faces a particular challenge with its current immigration policy. The US immigration policy is lacking and may lead to an outflow of human capital. The immigration policy issues are discussed in more detail under the sub-section “other means”, but need to be considered in this dimension as well.

Another challenge the US faces is the lack of permanent R&D tax credits. The US semiconductor industry invests 17% of sales into R&D, the highest investment rate in R&D compared to any other industry. The advances in semiconductors have been achieved by a sustained level of investment in Research & Development. Therefore, there is a clear need for strong and permanent incentives to encourage R&D efforts. While R&D tax credits were discussed in depth under the sub-section “Tax incentives” in this report, such tax credits may boost the R&D&I capabilities of the region. SIA is therefore calling for a permanent and enhanced R&D credit[192].

#### *3.2.1.4. R&D&I capacities in Asia*

While both Asian clusters have a strong R&D&I base, they can generally be characterised as less R&D-oriented. Zhongguancun in Beijing and China in general have a less R&D-oriented domestic industry and are focused on more traditional semiconductor products. Hsinchu Science Park is home to the leading edge semiconductor manufacturer TSMC, but is also highly focused on these manufacturing activities.

Both clusters, however, see a need to change this focus. China’s 12$^{th}$ Five-Year-Plan sets out six measures to stimulate the development of China’s software and semiconductor industries. The new policy will shift the emphasis for development away from pursuing capacity and output growth and towards improving R&D capabilities. The government will also introduce new tax breaks and incentives to encourage independent innovation. Taiwan’s semiconductor companies have welcomed the new policy and may decide to expand their investments in China to take advantage of the tax breaks on offer[193].

Taiwan’s government has implemented a long-term strategy in order to encourage non-profit R&D institutes to develop technology that subsequently finds its way to the industry. The main goal of the government is to reach growth through the growth of the industry. Hsinchu Science Park has been located near two prestigious technical universities, National Chiao Tung University and National Tsing Hua University, and is home to the Industrial Technology Research Institute (ITRI). ITRI has played a pivotal role in the cluster, most famously known for its spin-off TSMC. Moreover, a number of Electronics Research & Service Organization (ERSO) labs, a spin off ITRI, were moved to the area as well.

The availability of high-quality human resources is a key driving force for both clusters. A high proportion of Taiwanese university graduates decide to complete their further studies overseas, and subsequently return with multilingual skills as well as superior knowledge in their respective fields. The same holds for the Beijing cluster: a high number of students complete their studies abroad, and many engineers return to China after gaining valuable experience overseas. This is also stimulated through various policies, such as on-campus recruitment at world leading universities.

[192] SIA Tax Reform position paper available at http://www.sia-online.org/clientuploads/directory/DocumentSIA/Tax%20Reform/Tax%20Reform_Position_v8.pdf
[193] PwC (2011). “Continued growth: China’s impact on the semiconductor industry, update 2011”.

Three key elements were mentioned that may lead to boosting of the current R&D&I capacities in this region. These are:

- Encouraging the linkages between R&D organisations, academia and industry;
- Stimulate technology spin-offs from R&D organisations (for example, ITRI) to companies; *and*
- Stimulate technology transfer from the technologically-leading countries, for example, by encouraging locals to hold overseas positions or stimulating students to pursue a degree abroad.

#### *3.2.1.5. Lessons for Europe*

Compared to both the US and Asia, Europe has a strong R&D&I base. All analysed clusters, however, underline the importance of highly skilled human capital. For some European clusters, it was noted that they found it increasingly more difficult to attract such human capital. To stimulate this, Europe could aim to create research centres of excellence and encourage students to pursue technical studies. Moreover, following the Asian clusters, engineers or students could be encouraged to study or hold a position abroad. Following such a period abroad, they could be given incentives to return to Europe with newly gained knowledge.

In terms of possible improvements in Europe, the salaries in the public research sector can in some cases be made more attractive to ensure that there are enough researchers and technicians in universities and public research centres. The programmes offered by universities should be adapted to the needs of the cluster, as is the case in Tech Valley, where highly specialised programmes are offered for the semiconductor industry.

## *3.3. Effect of innovation policy and industrial policy regimes*

The effect of innovation policy and industrial policy regimes was analysed along a set of sub-dimensions. This part will focus in particular on measures supporting semiconductor manufacturing, measures supporting the creation of new market opportunities for semiconductors and measures to effectively attract a highly skilled workforce. Table 3-9 presents an overview of the key findings.

TABLE 3-9: Overview of key findings on innovation policy and industrial policy regimes

| 3 Innovation policy and industrial policy regimes | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| Individual descriptions | Commonalities |
| *Grenoble (Grenoble, France)* | **Measures supporting semiconductor manufacturing**<br>Various clusters emphasise the need to bridge the gap between design and manufacturing. Measures aimed at creating a better linkage between these two were therefore suggested. This can be done through, for example, networking or placing test facilities in the near proximity. Furthermore, the need for (R&D) tax incentives and access to finance were mentioned as key criteria. |
| **3.1 Measures supporting semiconductor manufacturing**<br>France is suggested to offer one of the most generous research tax incentives among the OECD countries. Other factors that make the Grenoble cluster attractive for manufacturing activities include influential structural projects, close involvement of local public authorities in the development of the cluster, and the availability of strong human capital, social capital and public research.<br><br>**3.2 Measures supporting the creation of new market opportunities for semiconductors**<br>Entrepreneurship opportunities in the cluster face the obstacle of insufficient supply of risk capital to support the creation and development of innovative SMEs. There is also a lack of entrepreneurial culture in the local scientific community and insufficient movement between university and industry. | |

**3 Innovation policy and industrial policy regimes**

**3.3 Measures to effectively attract a highly skilled workforce**
Monitoring of researchers in specific fields needs to be introduced. The French government intends to do so in order to increase the grants in the fields experiencing a lack of PhD students and to decrease grants in the fields with a surplus of PhD students.

***Silicon Saxony (Dresden, Germany)***

**3.1 Measures supporting semiconductor manufacturing**
Conditions that have been identified as the key challenges in Germany in relation to the semiconductor manufacturing industry[194] include access to capital, sustainability policies, IP rights, bank and economic policies, the intensity of competition, tax burdens and the investment in public-private partnerships for manufacturing.

**3.2 Measures supporting the creation of new market opportunities for semiconductors**
Ensuring that the educational institutions, research labs, and industries work collaboratively to translate the state's research into products that generate jobs.

**3.3 Measures to effectively attract a highly skilled workforce**
Germany needs to intensify its investments in education and science and strengthen educational opportunities in all areas of life. One of the strategies of Germany is to enhance the country's educational system in terms of both quality and breadth of impact, as well as improving permeability in all educational areas.

***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)***

**3.1 Measures supporting semiconductor manufacturing**
Measures aimed at creating a better linkage between production facilities and the cluster ecosystem are needed to effectively support manufacturing in the cluster. Furthermore, more general policies could support manufacturing, such as the ones that are aimed at lowering labour costs. European policy could be targeted towards measures which, through regional networking, aim to lift existing European fabs to a higher level. The Smart Specialisation movement could contribute to this.

**3.2 Measures supporting the creation of new market opportunities for semiconductors**
Member companies of the cluster aim to generate new market opportunities by tackling societal problems through occasional B2B meetings, brain storms, various topic work groups (as part of ARTEMIS & ENIAC programmes), networking activities to meet new potential partners, and participation in international tradeshows[195].

**3.3 Measures to effectively attract a highly skilled workforce**
Several measures were identified that require attention for the cluster:

- Increase the inflow of new students into technical education;
- Increase the level of participation of companies in education, in order to improve transfer from the educational system to the job market;
- Attract and retain international knowledge workers to compensate for gaps in domestic supply of personnel;
- Make the labour market more flexible in order to prevent losing knowledge and expertise in case of production volatility;
- A joint approach is needed, because problems concerning the workforce are felt in the whole ELAt area; *and*
- There is a particular need for high-quality infrastructure to keep relative distances small.

**Measures supporting the creation of new market opportunities for semiconductors**
Networking between educational institutions, research labs and industries was regarded as of key importance. In particular, collaborative initiatives between such parties were seen as a key aspect. The involvement of SMEs was often mentioned. SMEs were also said to face the obstacle of insufficient supply of risk capital. Therefore, access to finance, such as early stage capital, may need further attention.

**Measures to effectively attract a highly skilled workforce**
Most of the clusters identified a lack of highly skilled workforce, particularly through a low inflow of new students in technical education. Various measures were suggested to tackle this problem, which includes providing grants for PhD students in fields that lack such inflow (and reduce grants where there is a surplus), and investing in the education of science and technology. Moreover, a higher level of awareness among potential students and workers needs to be created.

[194] "Emerging Global Trends in Advanced Manufacturing", INSTITUTE FOR DEFENSE ANALYSES, March 2012, available at http://www.wilsoncenter.org/sites/default/files/Emerging_Global_Trends_in_Advanced_Manufacturing.pdf
[195] Interview with Key Stakeholder in the DSP Valley cluster region B

| 3 Innovation policy and industrial policy regimes | |
|---|---|
| *Silicon South West (South West England, UK)* | |
| **3.1 Measures supporting semiconductor manufacturing**<br>An initiative called catapult centres aim to build a bridge between early commercialisation and manufacturing capability. The SSW cluster organisation has also looked at establishing test facilities closer to the design source rather than manufacturing.<br><br>**3.2 Measures supporting the creation of new market opportunities for semiconductors**<br>The "Tradeshow Access Programme", an initiative from the UK Trade & Investment body, aims to raise the profile of UK groups and sectors at key exhibitions abroad. Still, more support is needed for measures stimulating early stage venture capital and investment into intermediaries to stimulate new market opportunities in the region and open up global market opportunities for start-ups and SMEs in particular.<br><br>**3.3 Measures to effectively attract a highly skilled workforce**<br>The UK Electronics Skills Foundation aims to raise awareness of careers in electronics, promote the value of the electronics industry to society and economy, and develop connections between companies and students in schools and universities. The Engineering and Physical Sciences Research Council is another UK-wide initiative aimed at skills enhancement, with sponsors granting awards for R&D and centres for doctoral training. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| Individual descriptions | Commonalities |
| *Silicon Valley (San Francisco Bay Area, US)* | **Measures supporting semiconductor manufacturing**<br>Regulations and taxation policies that hinder growth of innovative industries need to be eliminated. Particular focus areas may include R&D tax credits or tax exemptions to support company formations.<br><br>**Measures supporting the creation of new market opportunities for semiconductors**<br>There is a need to catalyse communities of innovation that link universities, federal laboratories, and industries together. |
| **3.1 Measures supporting semiconductor manufacturing**<br>The cluster needs regulations and taxation policies that stimulate the formation and growth of innovative industries. There is a clear need to eliminate those regulations and taxation policies that hinder growth. Areas of focus may include tax credits or tax exemptions to support company formation, state-wide regulations that affect the cost of doing business, and local regulations such as building codes that affect operating costs.<br><br>**3.2 Measures supporting the creation of new market opportunities for semiconductors**<br>There is a need to catalyse communities of innovation that link universities, federal laboratories, and industries within each of the diverse regions of California. Examples of emerging communities of innovation include Livermore Valley Open Campus (a partnership effort of Lawrence Livermore and Sandia National Laboratories), NASA Ames Research Park (a partnered effort with University of California), Mojave Space Port, and the Monterey Bay Research Crescent.<br><br>**3.3 Measures to effectively attract a highly skilled workforce**<br>The immigration policy requires urgent improvement (see 3.1.7 Other means). | |
| *Tech Valley (Albany, US)* | |
| **3.1 Measures supporting semiconductor manufacturing**<br>There is a clear need to eliminate those regulations and taxation policies that hinder growth. Areas of focus may include the provision of permanent R&D tax credits or tax exemptions to support company formation. Research facilities are also a key focal point. Innovation policy should focus on ensuring the presence of top-notch research and educational facilities and stimulating cooperation between industry and these research and educational facilities. Furthermore, the area needs to provide highly skilled labour capable of operating a semiconductor manufacturing facility.<br><br>**3.2 Measures supporting the creation of new market opportunities for semiconductors**<br>There is a need to catalyse communities of innovation that link universities, federal laboratories, and industries together.<br><br>**3.3 Measures to effectively attract a highly skilled workforce** | |

<table>
<tr><th colspan="2">3 Innovation policy and industrial policy regimes</th></tr>
<tr><td>The immigration policy requires urgent improvements (see 3.1.7 Other means).</td><td></td></tr>
<tr><td colspan="2">NON-EUROPEAN CLUSTERS: EAST ASIA</td></tr>
<tr><td>Individual descriptions</td><td>Commonalities</td></tr>
<tr><td>Zhongguancun (Beijing, China)</td><td rowspan="4">Measures supporting semiconductor manufacturing<br>Highly favourable tax conditions, generous public support, high quality of engineers, and top universities in the proximity were identified as factors that support semiconductor manufacturing.<br><br>Measures supporting the creation of new market opportunities for semiconductors<br>Both clusters express the need to increase the level of R&D activities in the cluster. This is especially fuelled by a desire to create, and own, leading-edge technology in the industry.<br><br>Measures to effectively attract a highly skilled workforce<br>The Asian clusters recognise the importance of attracting and retaining a highly skilled workforce. Both clusters to some extent offer preferential policies for high-tech professionals, but this is especially the case in the Beijing cluster. Moreover, engineers and students in China and Taiwan are encouraged to gain experience abroad and bring back the knowledge to their home country.</td></tr>
<tr><td>3.1 Measures supporting semiconductor manufacturing<br>China offers some of the most extensive public support and generous tax incentives in the world. Other factors include the high quality of engineers, top universities in the proximity and a strong domestic market that has historically been stimulated with rural development programmes.<br><br>3.2 Measures supporting the creation of new market opportunities for semiconductors<br>There is a need to shift from an output driven domestic semiconductor industry to a more R&D focused domestic semiconductor industry. The cluster, however, lacks effective IP protection.<br><br>3.3 Measures to effectively attract a highly skilled workforce<br>The Chinese government supports students and engineers to complete a study abroad. Once they have done so, they actively try to let them return to China. To establish leading R&D, it will however also be key to globally attract leading researchers. For this, ZGC is authorised by the Beijing municipal government to implement a series of preferential policies for high-tech professionals, especially those from overseas</td></tr>
<tr><td>Hsinchu Science and Industrial Park (Hsinchu, Taiwan)</td></tr>
<tr><td>3.1 Measures supporting semiconductor manufacturing<br>The Taiwanese government has provided considerable support, for example, low corporate taxes, attractive tax incentives and exemptions from duties. However, international cooperation is lacking, and technology transfer from overseas (for example, Albany in the case of TSMC) should be stimulated.<br><br>3.2 Measures supporting the creation of new market opportunities for semiconductors<br>Hsinchu has a government agency that provides a “one stop service” to the companies in HSP. The one-stop service ensures a beneficial environment for the high-tech industry and provision of common services to the companies in HSP.<br>It is also important that the foundries in HSP can offer the technology to produce products in new market opportunities. Moreover, increasingly more focus is placed on R&D in the cluster.<br><br>3.3 Measures to effectively attract a highly skilled workforce<br>HSP has put significant attention to talent cultivation and training programmes to enhance the technological competence and management capacity of company employees in HSP, for example, a Science Park Technology Talent Learning Network which aims to provide HSP employees with manpower training information, and a subsidy programme which aims at growing and developing potential talents for the science park. Moreover, engineers and students are encouraged to gain experience abroad and return afterwards.</td></tr>
</table>

### *3.3.1.1. The importance of innovation policy and industrial policy regimes for the semiconductor clusters*

The future competitiveness of the semiconductor’s industry is suggested to depend on addressing four fundamental challenges:

- Educating, retaining, and attracting enough scientists and engineers to grow the innovation economy;

- Ensuring that educational institutions, research labs, and industries work collaboratively to translate public research into products that generate jobs;
- Supporting entrepreneurial leadership, in particular by generating and attracting capital investments that grow the industry; *and*
- Creating a business climate that supports the formation, growth and retention of the industry.

Innovation and industrial policy regimes can play a key role in addressing these challenges and thus represents an area of key importance to the semiconductor industry. Moreover, all three analysed clusters largely owe their high number of enterprises to the numerous spin offs from existing companies, universities and research facilities.

#### *3.3.1.2. Innovation policy and industrial policy regimes in Europe*

***Measures supporting semiconductor manufacturing***

In order to attract and sustain manufacturing activities, clusters need regulations and taxation policies that stimulate the formation and growth of innovative industries. Areas of focus include tax credits or tax forgiveness to support company formation, regulations that affect the cost of doing business, and local regulations such as building codes that affect operating costs[196].

Measures aimed at creating a better linkage between production facilities and the cluster ecosystem were also suggested to effectively support semiconductor manufacturing. For example, the cluster organisation of DSP Valley and Eindhoven ASML cluster is currently working on linking the different production facilities in the cluster ecosystem. It aims to achieve this by extending its network activities to manufacturing companies in the semiconductor value chain, and not limit these to design[197]. Furthermore, more general policies could support manufacturing, such as the ones that are aimed at lowering labour costs. Examples of how government policy can achieve these lower labour costs can be identified in the automobile sector, where a specific tax system for work in shifts was installed[198].

In the UK, there is an initiative called catapult centres. This initiative aims to build a bridge between early commercialisation and manufacturing capabilities. The Silicon South West cluster organisation has also looked at establishing test facilities closer to the design source rather than to manufacturing.

***Measures supporting new market opportunities***

The entrepreneurship opportunities in the Grenoble cluster face the obstacle of insufficient supply of risk capital to support the creation and development of innovative SMEs. There is also a lack of entrepreneurial culture in the local scientific community and the presence of “invisible barriers” to

[196] Innovate 2 Innovation, An Assessment of California's Innovation Ecosystem, Phase II Report, August 2011, Prepared for the California Legislature by California Council on Science and Technology at http://www.ccst.us/publications/2011/2011i2i-ES.pdf
[197] Interview with Key Stakeholder in the DSP Valley cluster region A
[198] Interview with Key Stakeholder in the DSP Valley cluster region A

movement between university and industry[199]. These factors could slow down or even prevent the identification of new market opportunities and therefore should be assessed from the side of the public authorities.

Within DSP Valley and Eindhoven ASML, it was identified that pre-commercial public procurement (innovative procurement as coined by the Flemish government) can take on a key role in the creation of new markets. The policy tool “innovative procurement” was only recently created, hence its effect cannot be evaluated at this stage[200].

Policies aimed at focusing companies efforts in a certain specialisation based on member countries' key competences could lead to new market opportunities. It was argued by European stakeholders that the European semiconductor industry has better capabilities relative to Asia and the US concerning “More than Moore”. This specialisation could be leveraged to create new market opportunities.

***Measures to attract a highly skilled workforce***

The success of the Grenoble cluster is based on its large pool of human capital in the fields of research and technology. However, over the past few years, the number of researchers in Grenoble has been falling. The introduction of initiatives to attract more researchers to laboratories and enterprises to the cluster would be helpful. Similarly, there are not enough technicians to meet the cluster's requirements. This shortage is particularly slowing down the creation of clean rooms[201].

Silicon Saxony is currently influenced through all the measures and laws that already have been introduced and are in force. There are grants for gifted students, grants targeting career advancement, educational loans, programmes to support further training, and subsidies and support to students, pupils and trainees.

The mobility of academics has been loosened within the EU and for third party countries. Moreover, programmes have been introduced aiming at enhanced cooperation between industry, training preparation and transitions into vocational training. Programmes and financial support have also been made available, which tend to support students from disadvantaged backgrounds[202]. In addition, efforts are being made to attract more young people to enter training or studies in MINT fields (mathematics, informatics, natural science and technology). Moreover, particular interest has been placed on increasing the number of female students in the relevant study fields. At the same time, special consideration is being given to children and adolescents with migrant backgrounds, and to their parents.

***Key barriers and challenges***

In case of Grenoble, the cluster is encouraged by public funds to dedicate its research exclusively to the fields of micro- and nanotechnologies and embedded software without the possibility of major

[199] OECD (2009) “Clusters, Innovation and Entrepreneurship”, ed. Potter J. and Miranda G., Chapter 2 “The micro-nanotechnology cluster of Grenoble, France”, Centre of Entrepreneurship, SMEs and Local Development
[200] Interview with Key Stakeholder in the DSP Valley cluster region A
[201] OECD (2009) “Clusters, Innovation and Entrepreneurship”, ed. Potter J. and Miranda G., Chapter 2 “The micro-nanotechnology cluster of Grenoble, France”, Centre of Entrepreneurship, SMEs and Local Development
[202] “Emerging Global Trends in Advanced Manufacturing”, INSTITUTE FOR DEFENSE ANALYSES, March 2012, available at http://www.wilsoncenter.org/sites/default/files/Emerging_Global_Trends_in_Advanced_Manufacturing.pdf

public support for other fields. This situation increases the risk that Grenoble could become a "single sector" cluster without the necessary capacity to react to new market needs. Such exclusive focus is not the case for Silicon Valley and Zhongguancun.

Conditions that have been identified as the key challenges in Germany relating to the semiconductor manufacturing industry[203] include access to capital, sustainability policies, IP rights, bank and economic policies, the intensity of competition, tax burdens and the investment in public-private partnerships for manufacturing. These aspects need to be taken into account for Silicon Saxony if they wish to attract and retain semiconductor manufacturing in the cluster.

Bank loans are not typically used for financing innovation projects as they are considered a "non-bankable" risk and thus outside the scope of credit financing. In general, this problem needs to be addressed, and funds need to become more accessible for SMEs who are hampered by this. There is also a necessity to increase the financial direct incentives to offset manufacturing capital costs for semiconductor companies[204].

#### *3.3.1.3. Innovation policy and industrial policy regimes in the United States*

***Measures supporting semiconductor manufacturing***

For both US clusters in question, there is a need for regulations and taxation policies that stimulate the formation and growth of innovative industries, as well as a clear need to eliminate those regulations and taxation policies that hinder growth. Areas of focus may include tax credits or tax forgiveness to support company formation, state-wide regulations that affect the cost of doing business, and local regulations such as building codes that affect operating costs.

***Measures supporting new market opportunities***

There is a need to catalyse communities of innovation that link universities, federal laboratories, and industries. An example can be found in the Global 450mm Consortium abiding in Albany. The University at Albany partnered up with global industry leaders IBM, Intel, TSMC, GLOBALFOUNDRIES and Samsung to develop the next generation manufacturing technology. Moreover, leading tool makers such as ASML are also closely cooperating with the University at Albany and are expected to join in. Examples of emerging communities of innovation in Silicon Valley include Livermore Valley Open Campus (a partnership effort of Lawrence Livermore and Sandia National Laboratories), NASA Ames Research Park (a partnered effort with the University of California), Mojave Space Port, and the Monterey Bay Research Crescent.

***Measures to attract a highly skilled workforce***

A key issue that also applies here is the US immigration policy that needs to be amended. SIA called on Congress to support US innovation through high-skilled immigration reform through[205]:

[203] "Emerging Global Trends in Advanced Manufacturing", INSTITUTE FOR DEFENSE ANALYSES, March 2012, available at http://www.wilsoncenter.org/sites/default/files/Emerging_Global_Trends_in_Advanced_Manufacturing.pdf
[204] "Emerging Global Trends in Advanced Manufacturing", INSTITUTE FOR DEFENSE ANALYSES, March 2012, available at http://www.wilsoncenter.org/sites/default/files/Emerging_Global_Trends_in_Advanced_Manufacturing.pdf
[205] http://www.sia-online.org/public-policy/environment-safety-health/

- Exempting graduates with advanced STEM degrees from US universities from the EB green card cap to allow US employers to retain foreign-born employees already working in America; *and*
- Streamlining the path from student to permanent resident to allow US companies to access key talent, particularly individuals educated at US universities.

In terms of education, the following two conditions should hold:

- Making micro- and nanoelectronics a priority educational objective and development theme, ranging from awareness in the primary-to-high school education to developing multi-disciplinary curricula in academic training; *and*
- Launching programmes and curricula at all levels able to raise innovation awareness dramatically and to attract both new students and teachers to all disciplines in the nano- and microelectronic sciences.

Regarding education, Tech Valley boasts of some crucial institutions. One of the region's focal points in education has been nanoelectronics and nanotechnology. This has led to the creation of CNSE and the Center of Excellence in Nanoelectronics and Nanotechnology (CENN). As has been noted here before, both UAlbany and Hudson Valley Community College (HVCC) offer specific programmes for micro- or nanoengineering, or in the case of HVCC specifically for semiconductor manufacturing.

#### *3.3.1.4. Innovation policy and industrial policy regimes in Asia*

***Measures supporting semiconductor manufacturing***

The Beijing cluster is able to offer a relatively low cost environment for semiconductor manufacturing. Paired with extensive benefit packages, the cluster could from a financial perspective be an attractive location. Although the region has an abundance of cheap high skilled labour and excellent educational facilities, semiconductor manufacturing is less of a fit for the cluster's indigenous companies. Moreover, given the government's strong emphasis on moving away from an output-oriented semiconductor industry to an R&D-oriented industry, it seems unlikely that new measures for attracting semiconductor manufacturing will be introduced to the cluster in the short term.

In Hsinchu Science Park, semiconductor manufacturing has received considerable support from the Taiwanese government. For instance, low corporate taxes, attractive tax incentives and exemptions from duties all provide a clear advantage for firms operating manufacturing facilities. On the other hand, international cooperation is lacking and the new technology for manufacturing appears to be developed in Albany at the moment. The presence of TSMC at that research facility, however, ensures that the technology can be brought home and implemented in the Taiwanese clusters. Such technology transfer should be stimulated.

***Measures supporting new market opportunities***

There is a need to catalyse communities of innovation that link together universities, public laboratories, and industries within each of the diverse regions and Science Parks in the region. Collaboration efforts across different parks and different industries may also result in new technologies that can be used to take advantage of new market opportunities.

In the Beijing cluster, strong links between the government, private sector and universities are in place. Historically many ideas have found their way from universities to the market. These spinoffs, however, are often controlled by the universities themselves. While the innovations do indeed get to the market, entrepreneurial freedom may be limited due to a high degree of control from both the government and the universities.

Concerning developments in new market opportunities in Taiwan, it was mentioned that it is key that the foundries can offer the technology to produce such products. TSMC, for example, has been producing chips for Apple for some time. By staying abreast of current developments and by providing current manufacturing technologies, companies in Hsinchu Science Park can keep up with new market opportunities in semiconductors. Moreover, Hsinchu has a government agency which provides government service to the companies – a so-called "one stop service". This one-stop service was suggested to support companies in finding new market opportunities.

***Measures to attract a highly skilled workforce***

In Asia in general there is a strong focus on exact sciences. The Beijing area is no exception to this. There are plenty of highly skilled engineers in the region. Moreover, the Chinese government actively tries to attract overseas students and scientists. To facilitate overseas returnees, there are 29 overseas student pioneer parks. To attract more overseas talent, the Zhongguancun Administration Committee has also established liaison offices in Silicon Valley in California, Washington DC, Toronto, Tokyo, Munich and Hong Kong. There are more than 15,000 overseas returnees in Zhongguancun, who have in turn established more than 6,000 enterprises in the park. As a result, Zhongguancun has become a region with the most enterprises founded by overseas returnees in China.

Zhongguancun Science Park (Beijing) also offers incentives to attract highly skilled human capital/ These incentives include simplified procedures for investment and trade settlement, reduced tariffs on imported educational and R&D equipment, facilitation of medical care and entry-exit services, direct subsidies to high-quality professionals returning from overseas, and provision of low-cost housing.

Hsinchu Science Park has put significant attention to talent cultivation and training programmes to enhance the technological competence and management capacity of company employees in the cluster. For instance, there is the Science Park Technology Talent Learning Network which aims to provide employees in the cluster with manpower training information, and a subsidy programme which aims at growing and developing potential talent for the science park. Moreover, engineers and students are encouraged to gain experience abroad, and to return afterwards.

A low level of salaries has been identified as an issue, resulting in Taiwan's failing to retain local talent and attract foreign skilled workers[206]. There is thus a need for the Taiwanese government to intervene and launch appropriate measures in order to raise the level of wages. Further requirements on the policy to attract highly skilled labour globally would be the introduction of more open policies. The Taiwanese government needs to offer a more open attitude towards allowing foreigners to work here, and develop favourable regulations related to talent acquisition, including

[206] http://www.chinapost.com.tw/taiwan/national/national-news/2012/04/07/337089/Low-pay.htm

loosening guidelines on the kind of jobs foreigners are allowed to hold in Taiwan and providing easier access to residency rights[207].

#### 3.3.1.5. Lessons for Europe

***Measures supporting semiconductor manufacturing***

Although favourable tax policies were identified as a key measure to support semiconductor manufacturing, the specificities of such policies have been discussed under Section 3.1.2. Attracting and retaining highly skilled labour, however, is also an important feature.

***Measures supporting new market opportunities***

Regions outside Europe stressed the need to catalyse communities of innovation that link universities, federal laboratories, and industries together. In Europe, however, there are already many networks in place that aim to do so, ranging from cluster organisations to European funding programmes which aim to stimulate innovation.

The strong link between government, private sector and universities was particularly apparent in Asia. This strong link is also easily explained, given the high number of SOEs in these countries. The Asian regions particularly see value in the design part of the value chain as a new market opportunity, with China's 12th Five-Year Plan specifically having it as a target.

***Measures to attract a highly skilled workforce***

European clusters identified the challenges they face in attracting and retaining a highly skilled workforce. One of these aspects was the lack of a sufficient number of students and graduates in the field. In this respect, Europe may be able to learn from clusters located outside Europe. For the US clusters, it was identified that it is crucial for the semiconductor industry to make micro- and nanoelectronics a priority in education. It was further mentioned that more awareness for these subjects need to be created from primary school through to high school. Moreover, programmes and curricula need to be launched at all levels to raise awareness for this subject dramatically, and subsequently attract new students and teachers to this field. In Tech Valley (Albany, US), the Hudson Valley Community College, for example, offers a specific programme for semiconductor manufacturing. Such educational specialisation could be further explored in Europe.

Furthermore, the Beijing cluster offers preferential incentives for high-tech professionals, ranging from a quick administrative process to the option to defer personal income taxes for people working in the high-tech cluster. Such policies specifically aim to attract and retain highly skilled labour.

## 3.4. Technology transfer from research organisations and universities to companies

When analysing public policies and incentives regarding technology transfer from universities to industry, a distinction needs to be made between individuals and institutions. Individual scientists

[207] http://www.chinapost.com.tw/business/asia/b-taiwan/2008/10/20/179521/More-open.htm

face a trade-off between producing traditional university outcomes (good research, skilled students) and being entrepreneurial and producing applied research outputs (patents, spin-offs, and industrial contract research). Similar to individual scientists, university institutions are confronted with a trade-off between short-term and long-term objectives in research and teaching. On one hand, the quality of the university relates to the quality of the research done by its staff. Consequently, it is tied to the publication productivity of its scientists, the quality of students it is able to attract, and the jobs their students are able to get after graduation. On the other hand, increasing short-term financial constraints and national policies create incentives in universities to raise the level of collaborative and contract research along with commercialisation of research results[208].

#### *3.4.1.1. The importance of technology transfer from research organisations to companies for the semiconductor clusters*

Technology transfer from universities to companies in semiconductor clusters considerably depends on general technology transfer policies and measures. Empirical evidence suggests that for research institutions, the incentives that government puts in place for public sector organisations influence their perception of the value of certain actions. For example, the Bayh Dole Act in the US encourages licensing even at low rates, whereas in Europe, company and job creation is often seen by government agencies as the most important outcome. For companies, in turn, the value of such incentives is suggested to be less obvious. However, the introduction of specific frameworks for standard contracts and codes of practice can reduce the time and effort required from companies for negotiations with research institutions and can therefore deliver added value by releasing staff time to develop the business[209].

Table 3-10 provides an overview of the key findings on technology transfer from research organisations and universities to companies.

TABLE 3-10: Overview of key findings on technology transfer from research organisations and universities to companies

| 4 Technology transfer from research organisations and universities to companies | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | The "European model" of technology transfer represents a top-down approach. Governments tend to directly engage in the establishment either by financing and/or legislating of particular types of Technology Transfer Offices (TTOs). The form of incentives for public research organisations to engage in technology transfer is expected to affect not only the likelihood and efficiency of technology transfers, but also its orientation and the channels used for this purpose. |
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>Because of relatively low salaries in the public sector, young graduates from engineering schools increasingly target employment in large enterprises rather than research laboratories and universities. Furthermore, there is a gap in the number of technicians with respect to engineers. For example, there is no training of technicians for clean rooms. Although firms themselves could provide the appropriate technical training, more needs to be done by universities and other public actors.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>The connections between companies and universities have been present for a longer period of time than the inter-business connections. The focus of these interactions has | |

[208] "Monitoring and analysis of technology transfer and intellectual property regimes and their use", 2009 Expert Group on Knowledge Transfer Report, DG Research

[209] "Monitoring and analysis of technology transfer and intellectual property regimes and their use", 2009 Expert Group on Knowledge Transfer Report, DG Research

| 4 Technology transfer from research organisations and universities to companies | |
|---|---|
| mainly been placed on product design and less on manufacturing. The preferred means of cooperation has been related to informal communication even though contracts are used in most cases. The main motivation behind these partnerships has been identified as a lack of equipment capacity or labour skills of the private firms. | |
| ***Silicon Saxony (Dresden, Germany)*** | |
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>Scientists in the region are stimulated to start up new businesses, evidenced by the presence of organisations that aim to offer help in establishing a business. Furthermore, the universities in the region have a clear code of conduct regarding technology transfer and the cluster organisation of Silicon Saxony provides opportunities for industry and scientists to get in touch. Moreover, such interactions are also stimulated at the universities, both by PPPs and through, for example, a technology transfer network.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>Many technology transfer organisations are in place in the region. Furthermore, the organisations are clearly structured and provide a clear policy on IP disclosure. Universities in the region actively support technology transfer. This is also in line with the strong presence of PPPs, which greatly enable technology transfer in the cluster. | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>Employee mobility is being stimulated between different firms within the ecosystem. The goal is to have a platform which unemployed workers can approach to get a new job quickly. Furthermore, companies in the cluster offer Master and PhD students grants for conducting their studies within a business context. Companies also facilitate platforms for student internships, required for certain educational programmes. Finally, IMEC and KU Leuven frequently host seminars and workshops for both the private sector as well as university personnel.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>Policies and measures that effectively support technology transfer at the institutional level in DSP Valley and Eindhoven ASML and which are already present in the cluster include:<br>• The establishment of "Special Interest Groups" (SIG) aimed at creating alliances of partnerships among members (both academic and business oriented)[210];<br>• The establishment of "Technology Transfer Cells" at the universities (TU/e & KU Leuven), the KU Leuven R&D technology transfer cell recently received the "2008 IPTEC tech transfer award"[211];<br>• The establishment of the "KU Leuven Research & Development" (LRD) initiative; *and*<br>• The renowned IMEC research lab[212]. | |
| ***Silicon South West (South West England, UK)*** | |
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>Current measures promoting technology transfer include:<br>• Facilitating job mobility between universities and the private sector; | |

[210] www.dspvalley.com
[211] "Engineering the Future, expanding the innovation ecosystem; talent, knowledge and connectivity", ELAt & Brainport Operations B.V., 2008
[212] http://www2.imec.be/be_en/about-imec.html

| 4 Technology transfer from research organisations and universities to companies | |
|---|---|
| • Allowing part-time positions;<br>• Funding entrepreneurship through the SETsquared incubation programme; and<br>• The Learning Network, a collaboration between the semiconductor industry, academia and funding agencies which helps identify and develop courses and qualifications needed to develop the skills required by the industry.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>Measures supporting technology transfer are present at the institutional level, such as:<br>• Universities offering access to equipment and resources for start-ups;<br>• Development of a new science park called SPark just outside Bristol, which aims to incubate start-ups with the help of universities and research institutes;<br>• The SETsquared partnership involving the four universities in the region (Bath, Bristol, Surrey and Southampton); *and*<br>• Knowledge Transfer Partnerships, which help connect local companies to the knowledge base at universities. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | The “US model” of technology transfer follows a bottom-up approach. Policy focus is on creating requirements and incentives for public research organisations which stimulate them to intensify their commercialisation efforts. Public research organisations are completely free to choose the form, strategies and also the types of TTOs they view as most appropriate under prevailing circumstances. Historically, US universities have closer relations to industry than their European counterparts, and a larger share of their funding comes from private sources. |
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>Local research centres host various meetings. These meetings allow industry and university to come into direct contact with each other with the common purpose of university-industry cooperation. Additionally, student internship opportunities are provided through networks created in the research centres and programmes. Professors can use issues, topics, and materials brought to them by industry for their classes. This approach is reported to help departments attract highly motivated students.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>There are about 50 research centres linking Stanford University with industry. Additionally, Silicon Valley hosts several world-class start-up accelerators such as Y Combinator and SSE Labs. | |
| ***Tech Valley (Albany, US)*** | |
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>The College of Nanoscale Science and Engineering (CNSE) is the focal point of R&D, education and public-private partnerships. This advanced facility provides its own clean rooms for research and gives way to cooperation between leading companies on the one hand and faculty members or PhD students on the other.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>The University at Albany claims to be flexible and pragmatic in its approach to the different types of agreements that it executes with industry. It makes an effort to reach out to the private industry in both the region and the US as a whole. In order to provide the mechanisms through which they can partner with industry, they engage in collaborative research efforts, strategic alliances, evaluative testing, training and consultation and other forms of technology transfer. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)*** | Nowadays, both China and Taiwan are |

| 4 Technology transfer from research organisations and universities to companies | |
|---|---|
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>With many universities and research facilities in the area, it is important that these engage in technology transfer. Technology transfer in the cluster is actively stimulated. Top scientists are often invited to hold a position at company and incentives are in place which reward scientists engaging in technology transfer. Moreover, 29 overseas student pioneer parks facilitate technology transfer at the student level with the help of returning overseas students.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>Pushed by the government's strategy to encourage technology acquisition rather than selling imports and assembling knock-off parts, and pulled by economic benefits of the network, the ZGC Science Park has resulted in the clustering of similar high-tech start-ups and become a hotbed for many of China's high-tech products. | reported to have adapted their laws to create an IP system that responds to global demands and meets international standards.<br>In 1999, the Taiwanese government accepted the Basic Law of Science and Technology. China is reported to book significant improvements in its IP system in the recent years. |
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | |
| **4.1 Measures supporting technology transfer from universities to industry at the individual level (scientists)**<br>Informal network and gatherings in the cluster play an important role in knowledge transfer, with participation from more than 60% of science and technological professionals in the technological workforce. They provide opportunities to discuss particular problems and issues, or share common issues. Many gatherings have been organised spontaneously and irregularly.<br><br>**4.2 Measures supporting technology transfer from universities to industry at the institutional level (universities)**<br>The Taiwanese government accepted the Basic Law of Science and Technology in 1999, resulting in more universities setting up TTOs to market university inventions. The spatial proximity of the ITRI facilities, leading universities and specialised semiconductor companies at several value chain levels allows for access to specialised workers and new technological knowledge. In addition, the "National Science and Technology Platform for System-on-Chip" supports and targets the development of an SoC design platform in Taiwan. | |

### *3.4.1.2. Technology transfer from research organisations to companies in Europe*

The "European model" of technology transfer represents a top-down approach. Governments tend to directly engage in the establishment by financing and/or legislating of particular types of Technology Transfer Offices (TTOs). The form of incentives for public research organisations to engage in technology transfer is expected to affect not only the likelihood and efficiency of technology transfers, but also its orientation and the channels used for this purpose[213].

When analysing individual clusters, the following observations can be made.

In the case of Grenoble, one of the key challenges for the cluster refers to a reduction in the number of researchers and technicians. About one fifth of the cluster's employment is dedicated to research. However, because of relatively low salaries in the public sector, young graduates from engineering schools increasingly target employment in large enterprises rather than research laboratories and universities. Furthermore, there is a gap in the number of technicians with respect to engineers,

[213] "Monitoring and analysis of technology transfer and intellectual property regimes and their use", 2009 Expert Group on Knowledge Transfer Report, DG Research

suggesting that there may be a lack of appropriate technical or vocational training. For example, there is no training of technicians for clean rooms[214].

As for the institutional level, the connections between companies and universities in Grenoble have been present for a longer period of time than the inter-business connections. The focus of these interactions has mainly been placed on product design and less on manufacturing. The preferred means of cooperation has been related to informal communication even though contracts are used in most cases. The main motivation behind these partnerships is a lack of equipment capacity or labour skills of the private firms[215].

In Silicon Saxony, scientists in the region are reported to often engage in public-private partnerships. Moreover, they are stimulated to start up new businesses, evidenced by the presence of organisations that aim to offer help in establishing a new business. Furthermore, the universities in the region have a clear code of conduct regarding technology transfer and the cluster organisation of Silicon Saxony provides opportunities for industry and scientists to get in touch[216].

At the institutional level, several technology transfer initiatives exist such as two technology transfer centres CIMTT and The Center of Microtechnical Manufacturing (ZμP), as well as many other organisations. The organisations are reported to be clearly structured and to provide a clear policy on IP disclosure. Moreover, universities in the region actively support technology transfer.

In the case of DSP Valley and Eindhoven ASML, the cluster organisation promotes an idea that knowledge workers in the field of microelectronics do not necessarily have to spend their entire career at the same big company; instead, employee mobility is being stimulated between different firms within the ecosystem. The goal would be to develop a platform which unemployed workers can approach to get a new job quickly. Furthermore, companies in the cluster offer Master and PhD students grants for conducting their studies within a business context. Companies also facilitate platforms for student internships, which are required for certain educational programmes. Finally, IMEC and KU Leuven frequently host seminars and workshops for both private sector as well as university personnel. These events provide people with the opportunity to familiarise themselves with employment opportunities in either the public or private sector, and have already provided SMEs with valuable new staff.

Finally, in the Silicon South West cluster, the current level of public investment in programmes or initiatives aimed at supporting the technology transfer at the individual level is relatively low. There are some UK wide initiatives such as Industrial Fellowships from, for instance, the Royal Society[217] or the Engineering and Physical Sciences Research Council (EPSRC)[218], but there is no European wide programme to support such collaboration between industry and academia. The semiconductor industry in the cluster would benefit from an inter-university doctoral training centre, in which universities run a private sector sponsored training scheme at post-doctorate level. This is already successfully done in the field of chemical engineering.

[214] OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development
[215] OECD (2009) "Clusters, Innovation and Entrepreneurship", ed. Potter J. and Miranda G., Chapter 2 "The micro-nanotechnology cluster of Grenoble, France", Centre of Entrepreneurship, SMEs and Local Development
[216] http://tu-dresden.de/forschung/wissens-_und_technologietransfer/technologieallianz_e.v.
[217] http://www.bbsrc.ac.uk/business/people-information/industry-fellowship-scheme.aspx
[218] http://www.epsrc.ac.uk/funding/fellows/other/Pages/default.aspx

The semiconductor industry in the UK has been collaborating with colleges, universities, Regional Development Agencies and educational and funding agencies to build a so-called "Learning Network" in order to develop the required skills within the industry. This Learning Network is a collaborative network that identifies and develops courses and qualifications needed to develop the skills required by industry. Together, member organisations have developed a strategic vision to guide the participants in the network and which can be communicated to individual students, parents, staff and employers[219].

#### *3.4.1.3. Technology transfer from research organisations to companies in the United States*

The "US model" of technology transfer follows a bottom-up approach. Policy focus is on creating requirements and incentives for public research organisations which stimulate them to intensify their commercialisation efforts. Public research organisations are completely free to choose the form, strategies and also the types of Technology Transfer Offices (TTOs) they view as most appropriate under prevailing circumstances. Historically, US universities have closer relations to industry than their European counterparts, and a larger share of their funding comes from private sources[220]. Additionally, several references were made to the Small Business Innovation Research (SBIR) programme as a best practice in the field of supporting young technology companies (for more information, see Section 4.1 of this report).

In the case of Silicon Valley, about fifty research centres, including the Stanford Office of Technology Licensing, provide researchers and faculty with an opportunity to legitimately pursue applied knowledge. This is not only allowed but encouraged, as connecting the university and industry is the primary role of the centres and programmes. The centres host various meetings such as annual affiliates days and other public events to which previous and current affiliates and individuals who have been involved in the programme or centres are invited. These meetings allow industry and university to come in direct contact with each other with the common purpose of university-industry cooperation. Additionally, student internship opportunities are provided through networks created in these research centres and programmes. Professors can use issues, topics, and materials brought to them by industry for their classes. This approach is reported to help departments attract highly motivated students[221]. Additionally, Silicon Valley hosts several world class start-up accelerators such as the Y Combinator and SSE Labs.

In the case of New York, the College of Nanoscale Science and Engineering (CNSE) is the focal point of R&D, education and public-private partnerships. This advanced facility provides its own clean rooms for research and gives way to cooperation between leading companies and faculty members or PhD students.

[219] Dyson, C.M. (2001) "A learning network for the semiconductor industry", International Journal of Electrical Education, available at: http://www.manchesteruniversitypress.co.uk/uploads/docs/380290.pdf
[220] "Monitoring and analysis of technology transfer and intellectual property regimes and their use", 2009 Expert Group on Knowledge Transfer Report, DG Research
[221] Castilla E.J., Hwang H., Granovetter M., and Granovetter E. (2000) "Social Networks in Silicon Valley", Chapter 11 in "The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship", edited by Lee C.-M., Miller W.F., Rowen H., and Hancock M., Stanford: Stanford University Press

The University at Albany claims to be flexible and pragmatic in its approach to the different types of agreements that it executes with industry[222]. It makes an effort to reach out to the private industry in both the region and the US as a whole. In order to provide the mechanisms through which they can partner with industry, they engage in collaborative research efforts, strategic alliances, evaluative testing, training and consultation and other forms of technology transfer.

#### *3.4.1.4. Technology transfer from research organisations to companies in Asia*

Universities in Asia need to manage and clarify the rules for research results and IP rights and implement patent legislation. If these are unclear and unspecified, they could be a significant barrier to successful technology transfer. A clear and clean patent is considered as the essential element for technology transfer. Nowadays, both China and Taiwan are reported to have adapted their laws to create an IP system that responds to global demands and meets international standards.

China is reported to book significant improvements in its IP system in the recent years. Recent Patent Law amendments demonstrate China's desire to be an innovator, not a copier[223]. In the case of Beijing, with many universities and research facilities in the area, technology transfer in the cluster is actively stimulated by inviting top scientists to hold a position at company, and incentives are in place that give special rewards for scientists engaging in technology transfer. Moreover, 29 overseas student pioneer parks facilitate technology transfer at the student level with the help of returning overseas students. TTOs are located in the region, such as the Office of Science and Technology Development at Peking University. These offices aim to promote technical collaboration between the universities and private parties and transform technical achievements into practical applications[224].

In 1999, the Taiwanese government accepted the Basic Law of Science and Technology. This law is supposed to encourage university faculties to engage in research activity and patent application. Hence, more and more universities set up TTOs to market university inventions and intend to bring university research into practice[225].

As for Hsinchu Science Park, more than 60% of science and technological professionals in the technological workforce take part in informal social gatherings, such as reunions and book clubs, to keep and expand their professional networks. Many of the gatherings have been organised spontaneously and irregularly and led to immediate partnerships[226]. Furthermore, the spatial proximity of the ITRI facilities, leading universities National Chaio Tung University (NCTU) and National Tsing Hua University (NTHU), and the specialised semiconductor companies at several value chain levels, allow for access to several specialised workers and new technological knowledge.

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[222] Office of Technology Development, "Questions & Answers", University at Albany, available at http://www.albany.edu/research/TechDevFAQ.htm.

[223] Stoianoff N. (2012) "The Influence of the WTO Over China's Intellectual Property Regime", The Sydney Law Review, Vol. 34, No. 1, pp. 65-89, 2012

[224] http://english.pku.edu.cn/Administration1/506.htm

[225] Huang "Managing Technology Transfer in Open Innovation: The case Study in Taiwan", Modern Applied Science Vol. 4, No. 10; October 2010,

[226] Hu et al.( 2005): "Technology-based regional development strategies and the emergence of technological communities: a case study of HSIP" Technovation 25 (2005) 367–380, Taiwan

#### *3.4.1.5. Lessons for Europe*

At the individual level, there should be more uniformity in terms of legal aspects to facilitate exploitation within Europe, as well as the encouragement of close cooperation of academia with industry, for example, by having students working in companies while engineers from companies engage in projects in universities and research institutes.

In addition, the emergence of joint labs that are on industry premises but shared with universities and research organisations, as well as improvements in the sharing of expensive equipment and infrastructure inside and between clusters could be highly beneficial.

## *3.5. Technology transfer between companies and application customers*

The semiconductor industry forms part of a complex interaction among various industrial sectors. In general, demand for semiconductors does not emanate directly from end users, but rather is determined by the related end-customer markets. Most sales are generated by data processing (PC, servers), followed by communications, consumer electronics, industrial accounts (including medical, military, space) and the automotive industry[227].

Generally, in the semiconductor industry, the system knowledge can be developed through following forms: direct business alliances or partnerships between semiconductor companies and application companies, centres of excellence based on common interests, and complementary capabilities[228].

Customer expectations from semiconductor suppliers are shifting toward platforms, system integration, and services. This shift is mainly driven by emerging "More than Moore"[229] applications and the blurring of boundaries between semiconductor companies and Original Equipment Manufacturers (OEMs). Specialised semiconductor applications increasingly provide full-systems solutions to end-user customers. There is a trend for OEM systems design to migrate to semiconductor suppliers. This trend opens up new collaboration opportunities for providing full R&D development and engineering for such solutions[230].

The increasing price sensitivity and fragmentation of consumer markets faced by the chips industry is leading to the opening design centres in the locations with a supply of lower cost engineers, as a result of cost pressures from increased design complexity and an engineer shortage at home[231]. The industry is thus primarily seeking lower costs by locating selected operations offshore. Therefore, the relevant policy measures need to create economically favourable environment for semiconductor companies to open and/or keep their design centres in the cluster. Such measures, among others, are related to tax schemes and employee recruitment/retention costs.

[227] 2008 ESIA Competitiveness Report

[228] Zhang and Roosmalen (2009)"The Changing Landscape of Micro/Nanoelectronics", Chapter 1 in "Moore than Moore , Creating High Value Micro/Nanoelectronics system", edited by Zhang and Roosmalen, New York: Springer Science+ Business Media

[229] "More than Moore" (MtM): added values to devices are provided by incorporating functionalities that do not necessarily scale according to Moore's Law

[230] Zhang G.Q., Van Roosmalen A.J. (2009) "More than Moore: Creating High Value Macro/Nanoelectronics systems", Springer

[231] Brown C., and Linden G. (2009) "Chips and Change: How crisis reshapes the semiconductor industry", Massachusetts Institute of Technology

#### *3.5.1.1. The importance of technology transfer between companies and application customers*

Semiconductor companies may strongly benefit from proximity and access to the end-users, and this positive impact of the proximity to end-users is multi-dimensional. In general it allows for accessing the knowledge continuously and systematically. The companies profiting from the close engagement with the end-users are able to offer dedicated functions and technologies focused on specific application areas. It allows for exploring new market knowledge, which can be translated in new applications and solutions tailored to the needs of end-users since the close engagement with the end-users allows for easier and more precise discovery of their needs[232].

Table 3-11 provides an overview of the key findings on technology transfer between companies and application customers.

TABLE 3-11: Overview of key findings on technology transfer between companies and application customers

| 5 Technology transfer between companies and application customers | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| Individual descriptions | Commonalities |
| *Grenoble (Grenoble, France)* | **The role of semiconductor companies in cooperation with end-user industries**<br>All the analysed clusters aim to incorporate local end-user industries. The absence of key customers/end-user industries within the vicinity of the cluster region may sometimes be a barrier, and a more international orientation is needed.<br><br>**Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>EU-wide programmes such as ARTEMIS and ENIAC provide semiconductor companies easier access to end-user industries across Europe, but improvements can be made in terms of easing administrative requirements. Good international connectivity is also highly important to the cluster companies given the lack of a local market. |
| **5.1 The role of semiconductor companies in cooperation with end-user industries**<br>The co-operative connections within the cluster are a relatively new phenomenon for the cluster and are present particularly in the area of product design. This accounts for approximately 80% of interactions. For one third of the cases, the collaboration results in a specific product. The main reason for collaboration is the insufficient number of in-house labour and capital.<br><br>**5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>In France, the downstream value chain in the semiconductor industry is essential for the development of the market. The key end-user industries for semiconductors in France include entertainment electronics and aviation. | |
| *Silicon Saxony (Dresden, Germany)* | |
| **5.1 The role of semiconductor companies in cooperation with end-user industries**<br>The companies should specifically concentrate on new application and solution development in order to profit from the proximity to end-users and be simultaneously innovative.<br><br>**5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>In response to the financial crisis, the German federal government has introduced an initiative influencing the demand side. This initiative should strengthen electric mobility, and as a result could lead to higher demand for different electronic components for the automobile industry in the long run. | |
| *DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)* | |
| **5.1 The role of semiconductor companies in cooperation with end-user industries**<br>Incorporation of end-user industries in the DSP Valley and Eindhoven ASML semiconductor industry takes the following forms:<br>• Direct business alliances or partnerships between semiconductor companies and | |

[232] Zhang and Roosmalen (2009)"The Changing Landscape of Micro/Nanoelectronics", Chapter 1 in "Moore than Moore , Creating High Value Micro/Nanoelectronics system", edited by Zhang and Roosmalen, New York: Springer Science+ Business Media

| 5 Technology transfer between companies and application customers | |
|---|---|
| application companies, for example, between Philips and ASML;<br>• Centres of excellence based on common interests and complementary capabilities, for example, SIGs;<br>• Multinationals rallying their supplier industries in the close vicinity of their headquarters, for example, ASML; *and*<br>• Industry associations and other programmes that connect high-tech companies originating from different value chain activities.<br><br>**5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>Many examples exist both within the Belgian and Dutch part of the cluster. Point-one, for instance, is a programme aimed at the promotion of R&D collaboration among high-tech companies and research institutes in the Netherlands. Most of its member companies are active in the nanoelectronics industry, including ASML and many of its suppliers, NXP, IMEC, and Philips, among others. | |
| ***Silicon South West (South West England, UK)*** | |
| **5.1 The role of semiconductor companies in cooperation with end-user industries**<br>Many member companies constantly seek to calibrate their ideas and proofs of concepts against customers. The cluster is, for example, currently collaborating with Western Power Distributions on a large scale smart grid trial, with 100,000 users. The cluster organisation aims to link its member companies to these opportunities to gather customer data, which would otherwise be difficult to obtain.<br>The absence of a local market for silicon design products and the lack of key customers/end-user industries in the proximity of the cluster are key barriers.<br><br>**5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>National semiconductor trade association NMI is actively pursuing collaboration with end-user industries, such as the Electronics System Community, to develop a sustainable world-class of all electronics systems in the UK through seminars, peer group networking and enabling of R&D partnerships. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | **The role of semiconductor companies in cooperation with end-user industries**<br>For US clusters, incorporation of end-user industries faces cost-related challenges leading to the situation that increasingly more companies are deciding to move their facilities to other countries. Cost reduction can be made possible by opening satellite design centres elsewhere in the world, with some locations having much lower average engineering salaries, for example, Asia.<br><br>**Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>The relevant policy measures need to create economically favourable environment for semiconductor companies to open and/or keep their design centres in the clusters. Such measures, among others, are related to tax schemes and employee recruitment/retention costs. |
| **5.1 The role of semiconductor companies in cooperation with end-user industries**<br>For decades, Silicon Valley's semiconductor firms closely collaborated with local computer systems producers to develop innovative, high value-added products for semicustom and niche markets. Producers of computer systems depended on access to large quantities of low-cost memory chips, while mass producers of these commodity semiconductors required customised manufacturing equipment. However, price sensitivity and fragmentation of consumer markets have set different trends.<br><br>**5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>Due to cost-related challenges, increasingly more companies are deciding to move their facilities to other states/countries. Cost reduction is possible by opening satellite design centres elsewhere in the US, where some locations have average engineering salaries that are as much as 20% lower. Costs can be reduced even further by going offshore to Europe and Asia. | |
| ***Tech Valley (Albany, US)*** | |
| **5.1 The role of semiconductor companies in cooperation with end-user industries**<br>Cooperation with end-user industries still needs to be developed.<br><br>**5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries**<br>The region aims to open, and support, design centres across the state. This would require close cooperation with universities. One of the potential sites for a design centre is Boston. | |

<table>
<tr><th colspan="2">5 Technology transfer between companies and application customers</th></tr>
<tr><td colspan="2">NON-EUROPEAN CLUSTERS: EAST ASIA</td></tr>
<tr><td>Individual descriptions</td><td>Commonalities</td></tr>
<tr><td>Zhongguancun (Beijing, China)<br>5.1 The role of semiconductor companies in cooperation with end-user industries<br>Although Zhongguancun provides a strong entrepreneurial base with many innovative start-up companies, the cluster currently lacks a focus on R&D and incorporation of end-user industries.<br><br>5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries<br>No relevant policy measures were identified.<br>Hsinchu Science and Industrial Park (Hsinchu, Taiwan)<br>5.1 The role of semiconductor companies in cooperation with end-user industries<br>Taiwan’s free market economy and lack of government intervention means that Taiwanese companies need to ensure proximity to the end-users themselves. However, they may lack the funds or networks to do so, particularly for SMEs.<br><br>5.2 Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries<br>The provision of a “one stop service” in Hsinchu ensures a beneficial environment for the high-tech industry and provision of common services to the companies. However, a policy directly influencing the proximity to end-user companies is not present in the cluster.</td><td>The role of semiconductor companies in cooperation with end-user industries<br>Due to lower average salaries and other costs, Asian clusters are reported to be attractive locations for the opening of satellite design centres by companies from other regions. At the same time, no evidence was found that the incorporation of end-user industries is part of a governmental policy for the local industry.<br><br>Policy measures that help semiconductor companies get access to, and be in proximity of, end-user industries<br>No evidence was found that the incorporation of end-user industries is part of a governmental policy for the local industry.</td></tr>
</table>

### 3.5.1.2. *Technology transfer between companies and application customers in Europe*

All the analysed clusters aim to incorporate local end-user industries. The absence of key customers/end-user industries within the vicinity of the cluster region may sometimes be a barrier, and a more international orientation is needed.

EU-wide programmes such as ARTEMIS and ENIAC provide semiconductor companies easier access to end-user industries across Europe, but improvements can be made in terms of easing administrative requirements. Good international connectivity is also highly important to the cluster companies given the lack of a local market.

In Grenoble, several companies from other industries (end-user industries) such as textile and mechanics are closely working with STMicroelectronics and other semiconductor companies. Such co-operative connections within the cluster are a relatively new phenomenon for the cluster and are present particularly in the area of product design. This accounts for approximately 80% of interactions. For one third of the cases, the collaboration results in a specific product. The main reason for collaboration is the insufficient number of in-house labour and capital. However, the collaboration does not take place in a highly formal way (only about one-third of all collaborations are accompanied by a contract)[233].

In France, the downstream value chain in the semiconductor industry is essential for the development of the market. The key end-user industries for semiconductors in France include entertainment electronics and aviation. Significant public activities aiming at the strengthening of

[233] OECD (2009) “Clusters, Innovation and Entrepreneurship”, ed. Potter J. and Miranda G., Chapter 2 “The micro-nanotechnology cluster of Grenoble, France”, Centre of Entrepreneurship, SMEs and Local Development

the downstream value chain also serve to strengthen the suppliers in the semiconductor industry, since the strong demand for the semiconductors increases the pressure to innovate[234].

In Germany, in response to the financial crisis, the federal government has introduced an initiative influencing the demand side. This initiative should strengthen the electric mobility, and, as a result, could lead to higher demand for the different electronic components for the automobile industry in the long run[235].

Incorporation of end-user industries in the DSP Valley and Eindhoven ASML semiconductor industry takes the following forms:

- Direct business alliances or partnerships between semiconductor companies and application companies, for example, between Philips and ASML;
- Centres of excellence based on common interests and complementary capabilities, for example, SIGs;
- Multinationals rallying their supplier industries in the close vicinity of their headquarters, for example, ASML; *and*
- Industry associations and other programmes that connect high-tech companies originating from different value chain activities.

In the case of Silicon South West, many member companies constantly seek to calibrate their ideas and proofs of concepts against customers. The cluster is, for example, currently collaborating with Western Power Distributions on a large scale smart grid trial, involving 100,000 users. The cluster organisation aims to link its member companies to these opportunities to gather customer data, which would otherwise be hard to get.

Furthermore, UK's national semiconductor trade association NMI is actively pursuing collaboration with end-user industries, such as the Electronics System Community, to develop a sustainable world-class of all electronics systems in the UK through seminars, peer group networking and the enabling of R&D partnerships. NMI has already created a new logo and complementary slogan: "Together We're Better", to enforce this attempt[236]. The logic behind this new approach is simple – by including more steps of the value chain, more opportunities can be opened up, more support can be provided, and greater influence on behalf of the electronics industry and technical communities can be reached. This approach reflects an evolution in the industry, with more systems content appearing on the chip coupled with the increasing need to provide more than just the chip to customers[237].

Nevertheless, the absence of key customers/end-user industries within the vicinity of the cluster region is the key barrier for incorporating end-user industries in the Silicon South West cluster. In the southwest of the UK, there is no local market for silicon design products, which forces entrepreneurs to focus their trade internationally. Asia, for instance, hosts most of the semiconductor

[234] "Wettbewerbsfähigkeit der europäischen Wirtschaft im Hinblick auf die EU-Beihilfepolitik – am Beispiel der Nanoelektronik", Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag , Juli 2010, Arbeitsbericht Nr. 137

[235] "Wettbewerbsfähigkeit der europäischen Wirtschaft im Hinblick auf die EU-Beihilfepolitik – am Beispiel der Nanoelektronik", Buro fur Technikfolgen-Abschatzung beim deutschem Bundestag, Juli 2010, Arbeitsbericht Nr. 137

[236] http://www.nmi.org.uk/news/press-releases/nmi-drives-closer-interaction-between-semiconductors1

[237] http://www.nminet.org/profiles/blogs/nmi-is-expanding-because

manufacturing companies, which form the major customers for Silicon South West companies. Because of these large distances, supplier-customer spill over effects might less easily occur[238].

#### *3.5.1.3. Technology transfer between companies and application customers in the United States*

For US clusters, incorporation of end-user industries faces cost-related challenges leading to the situation that increasingly more companies are deciding to move their facilities to other countries. Cost reduction can be made possible by opening satellite design centres elsewhere in the world, with some locations having much lower average engineering salaries, for example, Asia[239].

The relevant policy measures need to create an economically favourable environment for semiconductor companies to open and/or keep their design centres in the clusters. Such measures, among others, are related to tax schemes and employee recruitment/retention costs.

For decades, Silicon Valley's semiconductor firms closely collaborated with local computer systems producers to develop innovative, high value-added products for semicustom and niche markets. Producers of computer systems depended on access to large quantities of low-cost memory chips, while mass producers of these commodity semiconductors required customised manufacturing equipment. The region's computer systems producers relied on face-to-face relations with local contract manufacturers in order to continually introduce new products for fast-changing markets[240]. However, price sensitivity and fragmentation of consumer markets have set different trends. Increasingly more companies are deciding to move their facilities to other states/countries. For Silicon Valley-based semiconductor companies, cost reduction is possible with the opening of satellite design centres elsewhere in the US, with some locations having average engineering salaries as much as 20% lower. Costs can be reduced even further by going offshore to Europe and Asia.

Concerning Tech Valley, cooperation with end-user industries still needs to be developed. The region is aiming to open, and support, design centres across the state. This would require close cooperation with universities. One of the potential sites for a design centre is Boston.

#### *3.5.1.4. Technology transfer between companies and application customers in Asia*

Due to lower average salaries and other costs, Asian clusters are reported to be attractive locations for the opening of satellite design centres by companies from other regions. At the same time, no evidence was found that the incorporation of end-user industries is part of a governmental policy for the local industry.

Although Zhongguancun provides a strong entrepreneurial base with many innovative start-up companies, the cluster currently lacks a focus on R&D. Hsinchu Science Park does have a governmental agency that provides a so-called "one stop service". Overall this one stop service ensures a beneficial environment for the high tech industry and provision of common services to the

[238] Marston L., Shanmugalingam S., and Westlake S. (2010) "Chips with everything: Lessons for effective government support for clusters from the South West semiconductors industry", NESTA, available at: http://www.nesta.org.uk/library/documents/Semiconductorsv10.pdf

[239] Brown C., and Linden G. (2009) "Chips and Change: How crisis reshapes the semiconductor industry", Massachusetts Institute of Technology

[240] Storper M., and Scott A.J. (1992) "Pathways to Industrialization and Regional Development", Routledge, New York

companies. However, a policy directly influencing the proximity to end-user companies is not present in the cluster.

#### 3.5.1.5. Lessons for Europe

A possible key enabler would be to provide new semiconductor technology hardware from European manufacturing sites to universities and other user-application developers at reduced rates, through incentives or in exchange for shared IP rights. This would allow for the development of new applications and creation of added value for both manufacturing companies and end users.

## 3.6. Clustering models

A popular ambition of many economic developers is to create a new 'Silicon Valley'. However, many successful clusters have a long bottom-up development story behind them. There are only few examples of high-technology clusters that had been successfully "planned" by government, and those that have been, tend to be regionally concentrated. Nonetheless, the Beijing cluster presents such a case-in-point.

Table 3-12 provides an overview of the key findings for the clusters in our sample.

TABLE 3-12: Overview of key findings on clustering models

| 6 Clustering models | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| Individual descriptions | Commonalities |
| *Grenoble (Grenoble, France)* | **Clustering model of the cluster**<br>Most of the clusters today can be best characterised as **a network system**. In some cases, however, it is better described as a grassroots[241] system with network elements, or as a grassroots system that transformed in a network system.<br><br>**The role of the cluster organisation** |
| **6.1 Clustering model of the cluster**<br>Network system[242]<br><br>**6.2 The role of the cluster organisation**<br>The cluster management group brings together actors in the cluster in order to stimulate collaborative research projects, disseminate the results of research and promote the cluster internationally.<br><br>**6.3 Specific characteristics of the cluster organisation** | |

[241] The *grassroots* system is driven by local initiation. Funding may come from community and local credit agencies. Research is highly applied and practical rather than scientific. Financial support and research competences are thus diffused locally, with a low amount of supra-local or national coordination. Local development agencies and local institutional actors play a predominant role. Coordination of interactions is based on social capital rather than formal organisations, and industry specialisation may be diverse, as in the case of regions with numerous distinctive clusters. For more information see Cooke F. (2006) "Regional innovation systems as public goods", UNIDO working paper

[242] The *network system* is more formalised and integrated at different levels: local, regional and national. Funding for innovation is more likely to engage public programmes with research of an applied but formalised nature being utilised. Some more scientific inputs may be accessed from industrial research institutes or universities. In such systems, coordination is rather high, with membership systems and effective knowledge circulation through seminars, workshops and associational networks. Specialisation by economic activity is more flexible than in grassroots systems. The network system is by no means fully governed or coordinated by market relations arising from corporate power or state planning modes of intervention. This is basically a partnership model of networking in which power relations nevertheless also accompany symmetry in the innovation interactions among stakeholders. For more information see Cooke F. (2006) "Regional innovation systems as public goods", UNIDO working paper

<table>
<tr><th colspan="2">6 Clustering models</th></tr>
<tr><td>• Six members in the Board of Directors (one of them is supported by three SME leaders); nine members in the Coordination Unit (one member appointed as Director of Micro-Nanotechnologies Cluster)<br>• Mix of public and private funds<br>• Multi-sectoral orientation</td><td rowspan="7">The cluster organisation has a common role to bring together actors to stimulate collaborative research projects. Moreover, European cluster organisations typically play a coordinating role. They are of an organised nature.<br><br>Specific characteristics of the cluster organisation<br>European cluster organisations are typically characterised as medium in size, have a multi-sectoral orientation and are funded by a mix of public and private funds. Furthermore, a management board is often in place that coordinates the activities.</td></tr>
<tr><td>Silicon Saxony (Dresden, Germany)</td></tr>
<tr><td>6.1 Clustering model of the cluster<br>Between grassroots and network models<br><br>6.2 The role of the cluster organisation<br>The Silicon Saxony Management GmbH covers activities in many areas focused on primarily on coordination and communication. Networking is one of the main activities of the group. Silicon Saxony Management GmbH also attempts to strengthen linkages between the research institutes and private companies in order to intensify the commercialisation and thus promote the development of the cluster. Its other activities cover operating a functioning web portal and taking control of the communicative tasks in order to promote cooperation. It also designs and implements specific strategies that aim to develop the cluster itself.<br><br>6.3 Specific characteristics of the cluster organisation<br>• Mix of public and private funds<br>• Multi-sectoral orientation</td></tr>
<tr><td>DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)</td></tr>
<tr><td>6.1 Clustering model of the cluster<br>Grassroots system which has transformed into a network system (hybrid model)<br><br>6.2 The role of the cluster organisation<br>The roles of the cluster organisation includes the following[243]:<br>• Match-maker between academia and industry;<br>• Facilitator of networking events;<br>• General information point on the cluster (including a directory of participating companies and other organisations); and<br>• Interfacing with government.<br><br>6.3 Specific characteristics of the cluster organisation<br>• Medium-sized cluster organisation<br>• Mix of public and private funds<br>• Multi-sectoral orientation</td></tr>
<tr><td>Silicon South West (South West England, UK)</td></tr>
<tr><td>6.1 Clustering model of the cluster<br>Grassroots model, with some elements of a network model<br><br>6.2 The role of the cluster organisation<br>The cluster organisation has a facilitative function in bringing various stakeholders together. It performs the following roles:<br>• Matchmaker between academia and industry;<br>• Facilitator of networking events;<br>• General information point on the cluster; and<br>• Creation of a test lab in Bath, to allow early-stage companies to access expensive testing equipment at low cost.<br><br>6.3 Specific characteristics of the cluster organisation<br>• Medium-sized cluster organisation<br>• Multi-sectoral focus<br>• Comprises a team of four experienced people in innovation networks (editorial</td></tr>
</table>

[243] http://www.dspvalley.com/

| **6 Clustering models** | |
|---|---|
| director, founder/CEO, director, network events coordinator)<br>• Mostly financed by venture capitalists, with small amount of funding from the national government | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| Individual descriptions | Commonalities |
| ***Silicon Valley (San Francisco Bay Area, US)*** | **Clustering model of the cluster**<br>The clustering models of the US based clusters are best described as **network systems**.<br><br>**The role of the cluster organisation**<br>The role of the cluster organisation varies, as **both clusters do not have a central cluster organisation with a coordinating role**. The roles of the cluster organisations thus vary from facilitating cooperation, to networking and to promoting the region.<br><br>**Specific characteristics of the cluster organisation**<br>The clusters are **not centrally coordinated by a single cluster organisation**. They do, however, have **a multi-sectoral focus**. |
| **6.1 Clustering model of the cluster**<br>Network system<br><br>**6.2 The role of the cluster organisation**<br>Since the 1970s, several non-profit organisations for collaboration have emerged in the valley. The Silicon Valley Leadership Group (set up in 1977 and previously known as Silicon Manufacturing Valley Group) has facilitated cooperation around issues of quality of life, education and infrastructure challenges such as transportation and energy, and tax regulation. Another organisation, The Joint Venture: Silicon Valley Network, established in 1993, is a network that provides analysis and action on issues affecting the region's overall economy and quality of life.<br><br>**6.3 Specific characteristics of the cluster organisation**<br>There is no central cluster organisation.<br><br>***Silicon Valley Leadership Group:***<br>22 FTEs, including President and CEO, six Vice Presidents; involves principal officers and senior managers of more than 365 member companies; non-profit organisation; private funding from membership fees.<br><br>***Joint Venture - Silicon Valley Network*:**<br>50 members in the Board of Directors that includes senior-level representatives from business, local and regional government, academia, labour and workforce organisations and the broader community; non-profit organisation; multi-sectoral orientation; is supported by numerous public and private organisations throughout the region - large and small - who invest in their projects and initiatives. | |
| ***Tech Valley (Albany, US)*** | |
| **6.1 Clustering model of the cluster**<br>Network system<br><br>**6.2 The role of the cluster organisation**<br>Tech Valley is not particularly organised, though there are certain structures in place that provide guidance. The Tech Valley association is the official cluster organisation. It is a council made up of all chambers of commerce in the State of New York. The association in particular has the stated goals of promoting the Tech Valley region and attracting human capital.<br><br>**6.3 Specific characteristics of the cluster organisation**<br>• Small cluster organisation without coordination efforts<br>• Multi-sectoral focus | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| Individual descriptions | Commonalities |
| ***Zhongguancun (Beijing, China)*** | **Clustering model of the cluster**<br>The clustering model of the Asian clusters is best described as a network system.<br><br>**The role of the cluster organisation**<br>The cluster organisations **play a central role**. They aim to **promote the development of the cluster**, and **provide a one-stop service** for companies in their cluster. They aim **to** |
| **6.1 Clustering model of the cluster**<br>Network system<br><br>**6.2 The role of the cluster organisation**<br>During the 12th Five-Year Plan period, Zhongguancun will further improve its Science and Future S&T Cities, and promote the development of the northern R&D service and high-tech industrial belt (which is located in North Haidian and South Changping) as well as the southern high-tech manufacturing and emerging industrial belt consisting of the Beijing Economic-Technological Development Area and partial areas of Daxing, Tongzhou and Fangshan districts. Moreover, the organisation actively supports the local | |

<table>
<tr><th colspan="2">6 Clustering models</th></tr>
<tr><td>companies by providing, for instance, benefits and finance programmes.<br><br>6.3 Specific characteristics of the cluster organisation<br>• No specific board members are communicated to the public<br>• Cluster organisation is a Committee part of the Beijing Administration<br>• Government initiative with heavy public support<br>• Multi-sectoral orientation</td><td rowspan="3">raise the competitiveness of the incumbent companies by stimulating collaborative R&D, and enhance the cluster's R&D capacities.<br><br>Specific characteristics of the cluster organisation<br>The clusters show great involvement of the public authorities. The management board includes people that hold government positions. Moreover, they are relatively large cluster organisations with a multi-sectoral focus.</td></tr>
<tr><td>Hsinchu Science and Industrial Park (Hsinchu, Taiwan)</td></tr>
<tr><td>6.1 Clustering model of the cluster<br>Network system<br><br>6.2 The role of the cluster organisation<br>SPA develops, organises and manages the science park. It aims to increase and improve the attractiveness of HSP as an investment environment by rending readily accessible services efficiently, promote wide-ranging technology upgrades with the goal of raising the competitiveness of park tenants, increasing environmental stringency in the park to create an environment conducive to sustainable development, and strengthen cooperation across industry, government, academia and research institutions to enhance the park's R&D capacity.<br><br>6.3 Specific characteristics of the cluster organisation<br>• Relatively large cluster organisation<br>• Multi-sectoral focus<br>• Located in six locations<br>• Consists of six divisions (Planning, Investment Services, Labour Relations, Business, Construction Management, Land Development)<br>• Has five offices (Information Management, Secretariat, Personnel, Accounting, Civil Service Ethics)</td></tr>
</table>

### *3.6.1. Clustering models in Europe*

Clusters in Europe can first of all be characterised by a degree of central coordination. While previously, the clustering primarily was initiated by large companies in a given region, the driving force in forming these centres of excellence or poles of competitiveness increasingly appears to be led by national and local authorities. Those seek to attract global players do so through local investment and tax incentives while providing the right infrastructures and ecosystem. More and more local authorities are targeting the opportunity to create jobs, attract skills, and maximise IP generation and return. The initiatives by governments, industries and knowledge institutions are transforming the regions into technology- and knowledge-based economy areas. Networks are built and resource allocation decisions are made, which create a base for new technological opportunities. Such initiatives have a diversified nature reflecting the needs of relevant stakeholder groups.

Cluster organisations in Europe play an active role when it comes to stimulating collaboration between the various cluster members. All of the analysed European clusters facilitate networking events with the goal to facilitate fruitful collaboration between the cluster members. Often, there is a strong focus on SMEs, arguing that they can bring an innovative advantage to already established companies. Moreover, cluster organisations in Europe often see themselves as matchmakers between academia and industry, underlining the importance of a good collaboration between the two. The clusters have a multi-sectoral focus and are best described as medium in size.

### *3.6.2. Clustering models in the United States*

Clusters in the US tend to represent concentrations of organisations without a central initiative. While both Silicon Valley and Tech Valley have to a large extent been developed via a bottom-up approach, considerable investments of both States and the federal government played a key role in stimulating this. These investments, however, did not come from cluster organisations, nor do cluster organisations to date have a high coordination role in Silicon Valley.

Silicon Valley and Tech Valley showcase a number of differences. Two "cluster-related" organisations were identified for Silicon Valley, which have a high degree of industry involvement. The Tech Valley organisation, on the other hand, is solely of public nature and mostly aims to promote the region and attract highly-skilled human capital. Both clusters, however, have a multi-sectoral focus. Companies in the clusters engage in collaboration mostly through their own networks, or through the various high-quality research institutions and/or universities. Facilitating this, however, is not a stated responsibility of the cluster organisations.

### *3.6.3. Clustering models in Asia*

Clusters in Asian countries, especially in the development markets, are mainly represented by scientific parks. More and more science and industrial parks, including R&D clusters, are emerging in China and Taiwan. Semiconductor companies with design centres located near these potential customers will be able to exploit the proximity advantage by having sustained interaction with them. Moreover, these science and industrial parks often aim to provide a one stop service to their cluster members, i.e. the provision of a high number of services by a single organisation. In Zhongguancun Science Park, for instance, the cluster organisation pays particular attention to areas such as financing. The cluster organisation actively helps incumbents of the cluster to get access to finance, acting as a mediator between financial companies on one hand and the cluster companies on the other.

The Science and Industrial parks are also categorised by a highly multi-sectoral focus. They often focus on a number of innovative industries to provide their services to. Furthermore, they typically aim to increase the attractiveness of the area and showcase a high involvement of public authorities. This high involvement of public authorities typically also brings about highly beneficial conditions for companies in the cluster, as is evidenced by the various policy measures discussed under dimension 1 of this report.

### *3.6.4. Lessons for Europe*

European clusters tend to be highly organised and to come from a central initiative. Although Silicon Valley is often looked at as the role model for clusters, each region may need to be treated differently. The US based clusters typically do not have highly organised cluster organisations, but represent a concentration of actors. Collaboration and matchmaking initiatives are often left to the market to form, though the state often stimulates such behaviour through, for example, innovation policies or technology transfer policies.

At the other end of the spectrum, we observe the highly organised science and industrial parks in the Asian clusters. These parks often showcase a high degree of involvement of public authorities. The analysed Asian clusters aim to provide a one stop service, which has the advantage for companies in the cluster in that they do not need to deal with various different parties for financing, advice or even permits. Stakeholders of the Hsinchu Science Park, however, stressed the importance of having facilitation measures in place, instead of providing a centralised coordination mechanism (i.e. a top-down approach).

European clusters in that respect appear balanced in their approach. While there is some degree of organisation, they often take the needs of industry into account. Nevertheless, it may be beneficial for European clusters to further explore the concept of a one stop service. Such a service may provide especially SMEs with a responsive and clear structure for their activities in the cluster.

## *3.7. Potential for new clusters and further networking and relevant policy measures*

This section is split up in two parts: the potential for new clusters and further networking, and policy measures supporting the cooperation with other clusters. They key findings for each part will be described here below.

### *3.7.1. Potential for new clusters and further networking*

#### *3.7.1.1. Potential for new clusters*

Several emerging hotspots were identified, which include New York, Washington D.C., Boston, Austin. The competition from international clusters has become particularly fierce. Areas like Bangalore (India) or Beijing (China), which possess highly educated labour force with much lower salaries, pose significant threats to existing semiconductor clusters, especially in older technologies further along in their lifecycle.

As long as the US remains the largest and most sophisticated market for technology products, new product design and leading edge innovation are expected to remain in there. However, Asian and European companies continue to enhance their ability to design, modify and adapt as well as rapidly commercialise technologies developed elsewhere. This makes them increasingly positioned to take new product ideas and technologies and quickly integrate and produce them in high volume at relatively low cost[244].

#### *3.7.1.2. Potential for further networking*

The potential for further networking varies per cluster. Table 3-13 provides an overview of the key findings.

TABLE 3-13: Overview of key findings on potential of further networking

| 7 Potential for new clusters or further networking |
|---|
| **EUROPEAN CLUSTERS** |

[244] Saxenian A. (2012) "The Silicon Valley-Hsinchu Connection: Technical Communities and Industrial Upgrading", Berkeley Planning Journal, 15(1), Department of City and Regional Planning, UC Berkeley

| 7 Potential for new clusters or further networking | |
|---|---|
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | There is cross-border potential for further networking, both within Europe and on a global level. |
| CEA-Leti is a partner in European partnerships involving the Dresden Nanotechnology Centre and Imec in Belgium. It also collaborates with CSEM in Switzerland, the Frauenhofer-Gesellschaft in Germany and Finland's VTT Technical research Centre, under the Heterogenous Technology alliance. In 2008, it entered into a partnership with the Californian research institute Caltech, for nanosystems VLSI (NanoVLSI: large scale integration). The aim of this partnership is to obtain nanoelectromechanical systems (NEMS) prior to mass production. | |
| ***Silicon Saxony (Dresden, Germany)*** | |
| The Dresden Nanotechnology Centre participates in European partnerships involving CEA-Leti and Imec. These partnerships open up potential for further networking. Given the current development in the 450mm manufacturing technology and a new manufacturing facility in upstate New York owned by GLOBALFOUNDIRES, there is potential to network with resources in Albany. It could be of particular interest to disseminate the knowledge that engineers flown in from Dresden are currently acquiring in GLOBALFOUNDRIES' new fab in collaboration with IBM. | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| Further networking for the DSP Valley and Eindhoven ASML cluster can be expected with members of the cluster network. Other potential for networking lies towards Aachen. The axis Leuven-Eindhoven concentrates on micro-electronics (DSP Valley and Eindhoven ASML epicentre), Leuven-Aachen deals with medical equipment, and Eindhoven-Maastricht-Aachen focuses on biomedical equipment. Policymakers on all "three sides" are keen on developing further cooperation, because the individual clusters do not have enough critical mass to propel the area into a world-leading innovation region on their own. | |
| ***Silicon South West (South West England, UK)*** | |
| The cluster sees potential in further networking and collaboration with the UK clusters in London (great source of venture capital) and Cambridge (comparable talent pool with the South West). Further engagement with any other design clusters at national, European or global levels would also be beneficial for the cluster. Global networking is especially important for the design stage of the value chain, and be especially influential among pre-qualified entrepreneurs in the SSW cluster. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| **Individual descriptions** | **Commonalities** |
| ***Silicon Valley (San Francisco Bay Area, US)*** | The potential for further networking lies at **a global level**. As the two clusters in our sample are rather specialised, they see more potential for further networking with other clusters on the global scale. This networking is particularly related to R&D. |
| There are several emerging hotspots that are successfully drawing companies away from Silicon Valley, for example, New York, Washington DC, Boston, and Austin. The competition from international clusters has become particularly fierce. At the same time, these clusters often are the key collaboration partners. Silicon Valley has a particularly close relationship with the Hsinchu Science Park in Taiwan. | |
| ***Tech Valley (Albany, US)*** | |
| The potential to network with other clusters is mostly in the field of R&D. Tech Valley is considered to be one of the hot spots in the world by Minalogic, which may open doors for further networking[245]. Moreover, there is interest from European parties (for example, IMEC) to collaborate with Albany's NanoTech Complex[246]. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| **Individual descriptions** | **Commonalities** |
| ***Zhongguancun (Beijing, China)*** | Whereas the Chinese cluster sees potential for further networking within its borders, both Asian clusters underline the **potential for further international networking, especially** |
| The Administrative Committee of Zhongguancun Science Park recently signed a cooperation agreement with Changchun National Hi-Tech Industrial Development Zone in Jilin province to promote cooperation and communication with technological innovations and industrial development. Given the nature of the cluster, there is a lot of | |

[245] http://www.minalogic.org
[246] Rulison, L. (2011). "IMEC responds to growth at Albany NanoTech". Times Union, available at http://blog.timesunion.com/business/imec-responds-to-growth-at-albany-nanotech/41815/

| 7 Potential for new clusters or further networking | |
|---|---|
| potential for ZGC to network with design clusters all over the world. | **with respect to collaborative R&D.** |
| ***Hsinchu Science and Industrial Park (Hsinchu, Taiwan)*** | |
| With the cluster's strong focus on manufacturing, there is potential for networking between European design companies (better access to manufacturing facilitates) and leading-edge Taiwanese foundries (greater access to end-user industries). Global networking is also particularly important for manufacturing in Taiwan, with increasingly costly new manufacturing technology requiring collaborative R&D efforts. | |

### *3.7.1.3. Potential for further networking in Europe*

In the European clusters, many networks are already in place. Nonetheless, for various clusters, potential for further cross-border networking was identified. This cross-border networking could be further explored both within Europe and on a more global level. Within Europe, stakeholders of DSP Valley and Eindhoven ASML saw particular potential for further networking with the Eindhoven-Leuven-Aachen Triangle (ELAt), especially towards Aachen. Moreover, the clusters acknowledged that further networking among similarly specialised clusters in Europe should be further explored.

In terms of global networking, it was mentioned that this was especially important for the design stage of the value chain. With leading-edge R&D institutions located across the globe, this potential could be further explored.

### *3.7.1.4. Potential for further networking in the United States*

The stakeholders of the US based clusters particularly underlined the potential for further networking at a global level. Silicon Valley already has particularly close relationships with Hsinchu Science Park (Taiwan), and Tech Valley has established itself as a semiconductor hot spot for the development of new manufacturing technology. Both provide an option for further networking. Concerning Tech Valley, IMEC has already stated it would be willing to further explore collaboration with Albany's NanoTech Complex[247].

### *3.7.1.5. Potential for further networking in Asia*

Both Asian clusters underline the potential for further international networking, especially with respect to collaborative R&D.

Concerning the potential for further networking for the Beijing cluster, the Administrative Committee of Zhongguancun Science Park recently signed a cooperation agreement with Changchun National Hi-Tech Industrial Development Zone in Jilin province. This cooperation agreement aims to promote cooperation and communication with technological innovations and industrial development. Given the nature of the cluster, there is potential for Zhongguancun Science Park to network with design clusters all over the world. As their goal is to establish innovative R&D, there is much to learn from more developed regions. The scientific base in Beijing offers an attractive human capital to carry out leading-edge research. However, some countries, such as the US, prohibit the export of IP, making collaboration more difficult.

[247] Rulison, L. (2011). "IMEC responds to growth at Albany NanoTech". Times Union, available at http://blog.timesunion.com/business/imec-responds-to-growth-at-albany-nanotech/41815/

Hsinchu Science Park has a strong focus on manufacturing. This also brings about a potential to network between European design companies (better access to manufacturing facilitates) and leading-edge Taiwanese foundries (greater access to end-user industries). Global networking is also particularly important for manufacturing in Taiwan, with increasingly costly new manufacturing technology requiring collaborative R&D efforts.

#### *3.7.1.6. Lessons for Europe*

All of the analysed regions identified the potential for further networking at a global level. Various factors, however, make the process more difficult. For instance, the weak state of IP rights and standards in China, the ban on IP exports from the US and the disincentive for leading-edge research institutions to share their knowledge with lesser developed regions, can make this difficult to realise. Further networking *within* Europe may therefore be more likely to occur, though regions are likely to gain more from further global networking.

### *3.7.2. Policy measures supporting cooperation with other clusters*

In the analysis, special attention was paid to the policy measures in different clusters that support cooperation with other clusters. Table 3-14 presents an overview of the key findings.

TABLE 3-14: Overview of key findings on policy measures supporting cooperation with other clusters

| 7 Potential for new clusters or further networking: policy measures supporting cooperation | |
|---|---|
| **EUROPEAN CLUSTERS** | |
| **Individual descriptions** | **Commonalities** |
| ***Grenoble (Grenoble, France)*** | Clusters have few policies in place that specifically support cooperation with other clusters. Despite this, a number of initiatives were identified in the sample. **A common recent initiative is found in the form of Silicon Europe, a formal collaboration in a "Regions of Knowledge" project**. Grenoble, Silicon Saxony, DSP Valley and Eindhoven ASML are involved in this project. |
| In October 2007, Minalogic became member of the Artemis European consortium for embedded technologies. In September 2008, Minalogic became associate member of Aeneas (Association for European NanoElectronics Activities), an initiative of the European Technology Platform ENIAC working in the nanoelectronics industry. In April 2009, Minalogic signed an agreement with GREX, the World Trade Centre of the Grenoble Chamber of Commerce and Industry, to provide further support to its members expanding beyond France.<br><br>The cluster is also part of the Silicon Europe initiative, which aims to secure Europe's position as the world's leading centre for energy efficient electronics. This transnational collaboration initiative involves four partners: Silicon Saxony (Dresden), Point-One (Eindhoven), Minalogic (Grenoble) and DSP Valley and Eindhoven ASML (Eindhoven/Leuven). | |
| ***Silicon Saxony (Dresden, Germany)*** | |
| The cluster is part of the Silicon Europe initiative, which aims to secure Europe its position as the world's leading centre for energy efficient electronics. This transnational collaboration initiative involves four partners: Silicon Saxony (Dresden), Point-One (Eindhoven), Minalogic (Grenoble) and DSP Valley (Eindhoven/Leuven). | |
| ***DSP Valley in combination with Eindhoven ASML (Eindhoven-Leuven, Netherlands and Belgium)*** | |
| The cluster is part of the Silicon Europe initiative, which aims to secure Europe its position as the world's leading centre for energy efficient electronics. This transnational collaboration initiative involves four partners: Silicon Saxony (Dresden), Point-One (Eindhoven), Minalogic (Grenoble) and DSP Valley (Eindhoven/Leuven). | |
| ***Silicon South West (South West England, UK)*** | |
| No policies specific to this area are present. Policies aimed at the professionalisation of European clusters would be beneficiary, in terms of the development of a common framework of ambitions, ideals, tools and techniques to simplify collaboration among | |

| 7 Potential for new clusters or further networking: policy measures supporting cooperation | |
|---|---|
| different clusters. | |
| **NON-EUROPEAN CLUSTERS: UNITED STATES** | |
| Individual descriptions | Commonalities |
| *Silicon Valley (San Francisco Bay Area, US)* | **Most measures in the clusters do not specifically aim to stimulate international networking**. Companies in the clusters use their own international networks to cooperate. |
| Not all measures currently present in the cluster aim to stimulate international networking. Design offshoring can face barriers related to national security, with the US government placing limits on the export of advanced encryption technology. Chips that employ such technology are difficult to design offshore. Accordingly, chip design must be compartmentalised, with the encryption block designed only in the US Otherwise, government approval, subject to possible delays, must be obtained in advance. | |
| *Tech Valley (Albany, US)* | |
| Most measures currently present in the cluster do not aim to stimulate international networking. For example, most of the R&D revolves around CNSE and while many global companies collaborate there, the research is of course done in Albany. International collaboration in Tech Valley thus concerns cooperation between international companies in Albany than collaborative research on a global level. Research within and between companies on a global level is, however, present in the cluster. GLOBALFOUNDRIES partnered with IBM to ramp up the production process in GLOBALFOUNDRIES' new fab. For this, GLOBALFOUNDRIES frequently flies in engineers from its other fabs around the world. Both parties then share important information with each other and collaboratively try to improve the manufacturing process. Moreover, the Global 450mm Consortium sets out to develop the new manufacturing technology at UAlbany. | |
| **NON-EUROPEAN CLUSTERS: EAST ASIA** | |
| Individual descriptions | Commonalities |
| *Zhongguancun (Beijing, China)* | **There are little commonalities in place**, as representatives from Taiwan stressed a belief in non-government intervention. In China, relatively few measures are in place. |
| There are relatively few measures in place that support direct cooperation with other clusters. Despite that, the Administrative Committee of Zhongguancun Science Park recently signed a cooperation agreement with Changchun National Hi-Tech Industrial Development Zone in Jilin province to promote cooperation and communication with technological innovations and industrial development. Furthermore, domestic companies are encouraged to engage in partnerships with leading global companies. By stimulating overseas education, engineers also gain valuable knowledge from leading research and educational institutions abroad. | |
| *Hsinchu Science and Industrial Park (Hsinchu, Taiwan)* | |
| None identified, due to the belief in non-government intervention in Taiwan's free market economy. | |

#### *3.7.2.1. Policies supporting further networking in Europe*

For the European clusters, few policies that specifically support cooperation with other clusters were identified to be in place. As was discussed above under the potential for further networking, there is potential for Europe to deepen the collaboration *within* Europe. A recent initiative of a number of European clusters underlines this potential. Silicon Europe is a formal collaboration in a "Regions of Knowledge" project in which three out of four European clusters in our sample participate. Specifically, Minalogic (Grenoble), Silicon Saxony (Dresden), and DSP Valley and Eindhoven ASML (Eindhoven/Leuven) are involved in this project. The initiative aims to improve collaboration among the clusters, but due to its recent start, its effects cannot yet be observed.

#### *3.7.2.2. Policies supporting further networking in the United States*

For both clusters in the US, no specific policies that stimulate further networking were identified. In Tech Valley, international cooperation is limited through the various organisations that play a role in the cluster. For instance, international companies collaborate with the College of Nanoscale Science and Engineering and use their own international network for further collaboration. International collaboration in Tech Valley thus concerns cooperation between international companies in Albany rather than collaborative research on a global level. There is, however, no formal policy in place that stimulates networking between different clusters.

#### *3.7.2.3. Policies supporting further networking in Asia*

For both Asian clusters, little commonalities could be determined. The Taiwanese authorities emphasised that such policies would be inconsistent with their belief in non-government intervention of Taiwan's free market economy. Nonetheless, they emphasised that further networking with especially design companies in Europe and the US could be beneficial. However, no formal policy was reported to be in place, although researchers and students are encouraged to gain experience abroad.

In the Beijing cluster, there are also relatively few measures in place that support direct cooperation with other clusters. The cluster, however, has recently signed a cooperation agreement with Changchun National Hi-Tech Industrial Development Zone in Jilin province. This cooperation agreement aims to promote cooperation and communication with technological innovations and industrial development. Furthermore, domestic companies are encouraged to engage in partnerships with leading global companies. By stimulating overseas education, engineers also gain valuable knowledge from leading research and educational institutions abroad.

#### *3.7.2.4. Lessons for Europe*

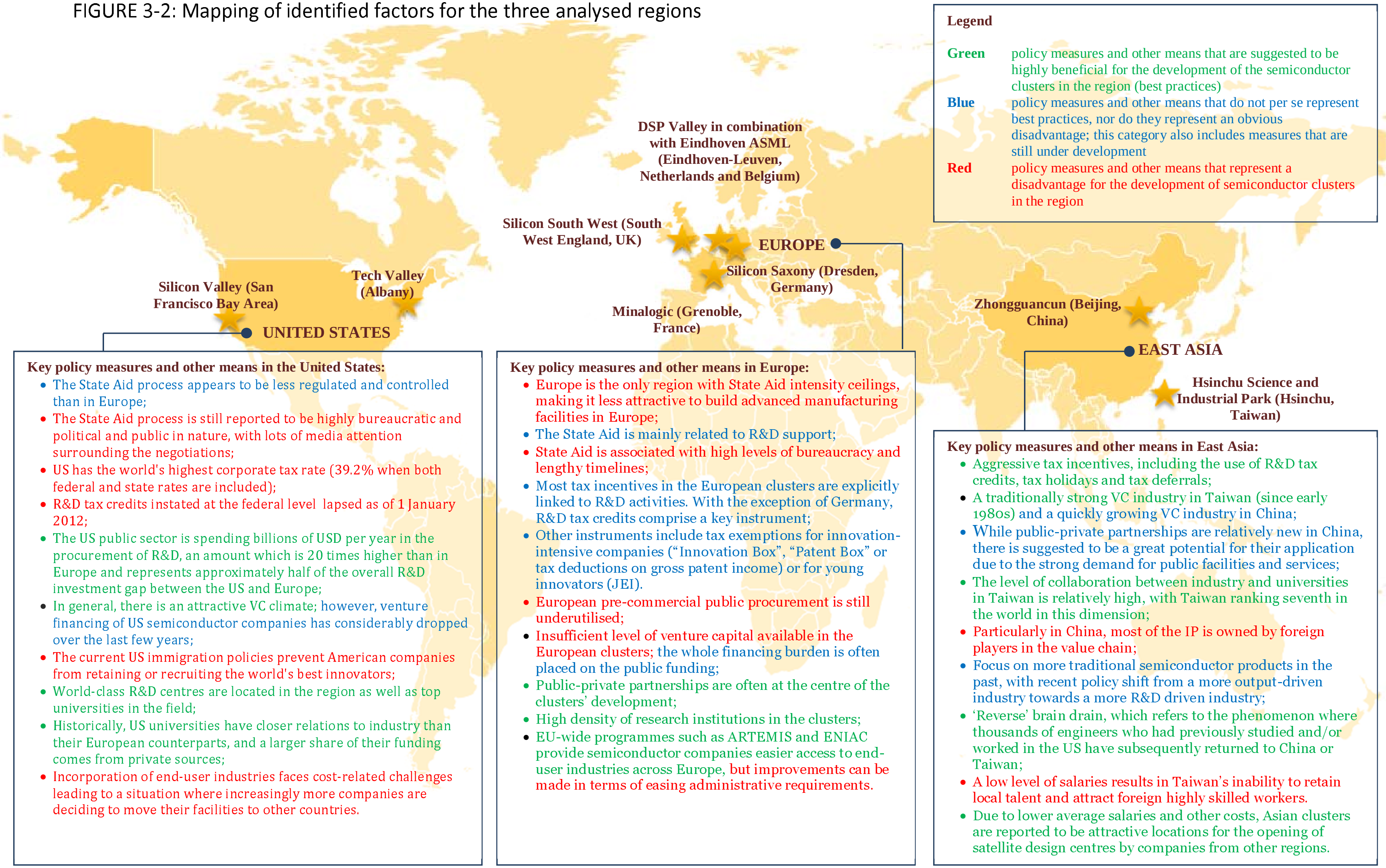
Europe gives access to a comparatively high number of networks that allow for networking between the clusters. Despite these networks, the clusters in our sample generally expressed that further cross-border networking could be explored. The Silicon Europe initiative may provide a ground for further cooperation, but it is too early to tell. Deepened cooperation contracts, such as those being experimented with in China, may be further explored to facilitate cross-border networking in Europe.

Furthermore, stakeholders in the clusters outside Europe identified that further networking at a global level may bring additional benefits. None of the clusters in our sample, however, appears to engage in large-scale global collaborations at the level of cluster organisations. Such collaborations may thus be further explored.

## *3.8. Factor mapping*

Figure 3-2 provides a map of the key policy measures and other means identified in the analysed regions. We group all the measures in three categories depending on their suggested positive/negative influence on the development of the semiconductor clusters.

FIGURE 3-2: Mapping of identified factors for the three analysed regions



# 4. Recommendations

In the previous chapter, based on a detailed analysis of four European and four non-European clusters, we identified a broad set of measures that are required to create, expand and keep semiconductor clusters in Europe competitive. In the current chapter, we present a set of policy recommendations on how to link national/regional level clusters and the identified measures to the future European level programmes, like Horizon 2020 and others. We elaborate on the measures that can and need to be adopted ***at the European level***.

The previous chapter clearly demonstrated a high complexity of factors influencing the development of the semiconductor clusters. We identified dozens of general and specific policy measures and other means that are suggested to have an effect on the semiconductor industry. Addressing all of these measures in the recommendations chapter would be a utopian task, with a high risk of diluted added value of this chapter for the policy makers and other key stakeholders such as industry, academia, cluster organisations and investors. We therefore focus on the policy areas that, based on the results of the public consultation conducted in the context of this study (see Section 2.5.3 Public consultation), have been nominated by the stakeholders as being key for the competitiveness of the European semiconductor industry. The top five includes the following measures:

(1) Measures to stimulate technology transfer from research organisations to companies;
(2) Measures to stimulate R&D&I skills;
(3) Tax incentives;
(4) Innovation and industrial policy regimes; *and*
(5) State Aid.

Below we elaborate on each of these measures in detail. In order not to lose the momentum, it is recommended to implement the proposed measures ***within the next year***. Most of these measures are of general nature and hold for the whole KETs domain.

## 4.1. Measures to stimulate technology transfer from research organisations to companies

Two types of recommendations can be made with regard to the measures to stimulate technology transfer from research organisations to companies: (1) introducing an integrated European-level SBIR programme with strong coordination mechanisms and competitive budgets; and (2) ensuring uniformity in terms of legal aspects to facilitate exploitation of research results within Europe. Below we elaborate on each of these recommendations in detail.

### 4.1.1. Introducing an integrated European-level SBIR programme

The phase between research outputs of universities and actual innovation/commercial production by companies is commonly referred to as the “valley of death”. Countless potentially valuable ideas have ‘died’ and continue to ‘die’ during this phase, for a number of reasons which, among others, include scarce financing for early- or mid-stage technology companies, poor interaction between university and industry, and high IP protection costs.

The "valley of death" exists in the innovation cycle everywhere in the world, not only in the EU. However, for a number of reasons, the EU's valley is often reported to be wider and more difficult to cross than valleys of some other regions (for example, the US and East Asia). Achieving the objectives of the Innovation Union[248] initiative and closing the innovation gap with EU competitors requires finding ways to reduce the length and breadth of the EU's "valley of death" and to better support those who undertake to cross it.

The financing of the innovation cycle is normally divided into three main phases: (1) funding of 'blue sky' or basic R&D (currently funded by the Framework Programme (FP)); (2) funding of activities related to demonstration and early introduction to the market (currently funded by CIP[249]); and (3) funding of the commercialisation of a new product or service. The first phase is typically covered by public funds as, due to the risky nature of innovation and uncertain economic returns, it is difficult to attract private investment at this stage, with private investors usually entering during the second and third phases. Consequently, public funding typically decreases throughout the innovation cycle, with private funding having an opposite trend. At the same time, the costs associated with the innovation cycle increase steadily from basic research up to product development. Costs for post-research activities, i.e. testing, validation, field trials, and pre-development, are typically between ten to twenty times higher than those of stand-alone research, which creates the abovementioned "valley of death".

Under the previous FPs, thousands of projects have been supported, providing primarily phase one and phase two funding. Within EU's Seventh Framework Programme for Research (FP7), so-called Collaborative Projects (CP) distinguish between "Small and Medium-scale focused Research Projects" and "Large-scale Integrating Projects". Funding covers activities in research, demonstration, training, innovation, dissemination and management. FP projects have a typical duration of three to four years which is often not enough to go through all stages of the innovation cycle, which spans from basic R&D to the competitive market. The total length of innovation cycle depends on the sector and the type of innovation, but for highly complex technologies, it is often 15 to 20 years long if we take basic research into account and implies high capital intensity. Hence, ***semiconductor innovations require a consistent multi-year programmatic approach split into several phases***.

In order to sustain Europe's competitiveness, ***the new approach therefore needs to cover the whole innovation cycle, from support to basic research and major research infrastructures to the promotion of open markets for new innovative products***, thereby making full use of regulations, standards, public procurement and IP rights[250]. There is a clear need for extending the scope of funding towards closer to market activities[251].

One of the best practices from other regions identified in the course of this study refers to the *Small Business Innovation Research (SBIR) programme* currently available in the US We already mentioned this programme in Section 3.4 of this report. SBIR aims to encourage domestic small businesses to engage in Federal Research/Research and Development (R/R&D) that has the potential for

248 http://ec.europa.eu/research/innovation-union/index_en.cfm

249 Competitiveness and Innovation Framework Programme, see http://ec.europa.eu/cip/

250 See also Horizon 2020 - The Framework Programme for Research and Innovation - Impact Assessment Report, pp. 24-25

251 See also PwC's report on "EU budget support for research and innovation" prepared for the Directorate General for Internal Policies of the European Parliament, June 2012, available at http://www.europarl.europa.eu/committees/en/cont/studiesdownload.html?languageDocument=EN&file=74671

***Rather than implementing similar national schemes in individual European countries, there is a need to develop an integrated European-level SBIR programme with strong coordination mechanisms and competitive budgets. At this moment, the evidence suggests that existing attempts are not yet that successful in Europe as in the US not because of the idea itself, but because of the way it is implemented or because it is still too early to judge on the impact.***

commercialisation. Through a competitive awards-based programme, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialisation[252]. SBIR was launched in 1982, and is suggested to be the world's largest seed capital programme for science and technology businesses[253]. Some of the most innovative US companies have received early stage financing from SBIR, including Apple, Compaq and Intel. ***A key feature of the programme refers to the absence of a requirement of matching funds from the company's side which is often beyond the means of start-ups and small businesses, i.e. the programme implies 100% funding plus a small profit element***.

The US SBIR model has already been adopted by some Asian countries (e.g., Taiwan, Korea, Japan). In Taiwan, in accordance with the provisions of the Ministry of Economic Affairs (MOEA) Incentive Scheme for Enterprises to Develop Industrial Technologies, a similar initiative was introduced in 1999. The objective of the programme is to encourage Taiwan's SMEs to advance the development of innovative new technologies and new products, thereby strengthening the competitiveness of the SME sector[254].

**Three phases of the US Small Business Innovation Research (SBIR) programme[255]**

*Phase I*. The objective of Phase I is to establish the technical merit, feasibility, and commercial potential of the proposed R/R&D efforts and to determine the quality of performance of the small business awardee organisation prior to providing further Federal support in Phase II. SBIR Phase I awards normally do not exceed 150,000 USD of total costs for six months.

*Phase II*. The objective of Phase II is to continue the R/R&D efforts initiated in Phase I. Funding is based on the results achieved in Phase I and the scientific and technical merit and commercial potential of the project proposed in Phase II. Only Phase I awardees are eligible for a Phase II award. SBIR Phase II awards normally do not exceed 1,000,000 USD of total costs for two years.

*Phase III*. The objective of Phase III, where appropriate, is for the small business to pursue commercialisation objectives resulting from the Phase I/II R/R&D activities. The SBIR programme does not fund Phase III. Some Federal agencies, Phase III may involve follow-on non-SBIR funded R&D or production contracts for products, processes or services intended for use by the US Government.

Some differences can be observed when comparing the US and Taiwanese models: (1) SBIR in US takes the form of procurement of R&D addressing a list of specific topics defined by the government, while SBIR in Taiwan is designed as subsidies without any assumed thematic restriction; (2) while US model implies 100% funding, in Taiwan, companies must provide at least 50% of R&D funding

[252] http://www.sbir.gov/about/about-sbir
[253] Connel D. (2006) "Secrets" of the World's Largest Seed Capital Fund: How the United States Government Uses its Small Business Innovation Research (SBIR) Programme and Procurement Budgets to Support Small Technology Firms", Centre for Business Research, University of Cambridge, available at http://www.cbr.cam.ac.uk/pdf/SBIR%20Full%20Report.pdf
[254] http://www.sbir.org.tw/SBIR/web/Exist_eng.aspx
[255] http://www.sbir.gov/about/about-sbir

themselves; (3) while in the US, only award winners of Phase I are considered for Phase II, in Taiwan, those phases are independent[256].

The Taiwanese government may fund technological projects that have a potentially high social return or that reflect the government's own objectives. Such government funding supports the recipient (the technology or the firm) even if the recipient may be initially inferior to competitors. The latter has led to the criticism that the government, rather than market, is ''picking winners''[257].

**Small Business Innovation Research (SBIR) programme in Taiwan[258]**

Under Taiwan's SBIR plan, SMEs can apply for subsidies covering ***up to 50%*** of the total cost of R&D. This government funding support helps to reduce the costs and the level of risk that SMEs must bear when engaging in innovation or R&D. By encouraging SMEs to undertake the development of new industrial technologies and products, the SBIR plan aims to boost overall private-sector R&D spending, speed up industrial upgrading and strengthen Taiwan's international competitiveness.

Awardees ***must be local companies*** with less than 200 employees or capital less than 80 million[259].

The applications are categorised into three phases:

*Phase I:* 1,000,000 NT $ (or about 26,000 EUR) total governmental subsidy for 6 months.

A small-scale experiment or statistical analysis of the creative concept that can potentially benefit industries so as to validate that concept as being viable. Applicants must describe the key problems addressed, the creative concept they intend to use, anticipated benefits to industries, as well as relative R&D track records and implementation plans.
*Phase II*: 10,000,000 NT $ (or about 262,000 EUR) total governmental subsidy for 2 years.

R&D of a product, production method or service mechanism based on a tangible and feasible creative concept expected to benefit industries. The R&D of a production method can extend to the trial production or ramp-up stage. Applicants must describe the key problems addressed, the creative concept they intend to use, anticipated benefits to industries, as well as relative R&D track records and implementation plans.

*Phase II+*: 5,000,000 NT $ (or about 131,000 EUR) total governmental subsidy for 1 year.

This involves the implementation and wide application of R&D results in Phase 2 so as to meet market and customer demand. The focus of R&D extends from the emphasis on the design of technical innovations to the production of the technical application. They may include engineering techniques, moulding development techniques, product design, trial production and ramp-up techniques, or primary market surveys. Applicants must describe the application of the developed technique, feasible implementation, commercialisation target and expected benefits.

No comparable SBIR equivalent was detected in China. Nevertheless, several measures have been introduced there recently to stimulate the technology transfer from research organisations to companies. The National Medium- and Long-term Programme for Science and Technology

[256] Chien-Wen Huang, Pin-Yu Chu, Fung-Wu Lee (2005) "Evaluation of Government Subsidy R&D Program – The Comparative Study of SBIR between Taiwan and the US", Proceeding of the Second Workshop on the Knowledge Economy and Electronic Commerce, available at http://moe.ecrc.nsysu.edu.tw/Chinese/workshopC/2005/SYS-05.pdf
[257] Chien-wen Huang, Jen-Chun Lo, Pin-Yu Chu (2006) "The policy impact of public sponsored Research & Development Program in Taiwan", Proceedings of the 11th Annual Conference of Asia Pacific Decision Sciences Institute Hong Kong, June 14-18, 2006, pp. 138-143
[258] http://www.sbir.org.tw/SBIR/web/Exist_eng.aspx
[259] Chien-Wen Huang, Jen-Chun Lo, Pin-Yu Chu (2006) "The policy impact of public sponsored Research & Development Program in Taiwan", Proceedings of the 11th Annual Conference of Asia Pacific Decision Sciences Institute Hong Kong, June 14-18, 2006, pp. 138-143

Development (MLP) 2006-2020 settled innovation as a fundamental national strategy and explicitly highlighted systemic usage of public procurement. The measures under MLP are reported to have raised the awareness of innovation-oriented public procurement among various stakeholders and have facilitated commercialisation of several strategic technologies[260].

Several SBIR equivalents also exist in Europe (e.g., the SBRI programme in the UK and the SBIR programme in the Netherlands; other European countries that have adopted an SBIR-type programme include Sweden and Finland[261], while Austria, Spain, Ireland and France have shown an interest in starting their own SBIR-like initiatives). ***However the European equivalents are reported to be less successful for a number of reasons including lack of participation from government departments[262], too short time period and too small scale to judge on the impact ,and more modest funds than in the United States.***

**Dutch Small Business Innovation Research (SBIR) Programme: a pioneer experience[263]**

The aim of the Dutch SBIR programme is to use the creativity of (small) entrepreneurs to solve societal problems. Entrepreneurs develop new products, services or processes that will be available in three to five years time. The best ideas compete for funding. The programme started in 2004.

The Dutch SBIR programme is considered to be a pre-commercial public procurement since it requires the development of prototypes for solving specific problems. The prototype must be developed to a level where the risk of using it is reduced or none.

The Dutch SBIR programme is positioned as a "European" version of the US SBIR programme. One of the differences is that the EU version is available to all enterprises to follow the principle of non-discrimination. However, the programme is suggested to be unattractive for big enterprises given the amount of funds that is offered. As a result, 90% of participants are SMEs.

The programme provides 100% funding and consists of three phases:

Phase 1: Feasibility, six months, maximum 50,000 EUR
Phase 2: Development, two years, maximum 450,000 EUR
Phase 3: Market introduction, no funding.

**Small Business Research Initiative (SBRI) programme in the United Kingdom**

The SBRI programme introduced in 2001 aims to use the power of government procurement to drive innovation. It provides opportunities for innovative companies to engage with the public sector to solve specific problems.

The first feasibility phase lasts generally two to six months, with contracts typically worth up to a maximum of 100,000 GBP.
Following a second assessment stage, a subset of these ideas may be awarded a second phase contract which can be for up to two years and worth a maximum of 1,000,000 GBP. These contract values and durations are dependent on the challenge being addressed. This second phase will generally be for the development of a prototype or demonstrator. After completion of the second phase, companies are expected to commercialise the resulting product

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260 Yanchao Li (2012) "Innovation-Oriented Public Procurement of School Computers: A comparative case study in the contexts of the UK and China", Manchester Institute of Innovation Research (MIOIR), UNDERPINN Conference, March 22nd 2012, MBS
261 http://www.nsba.biz/docs/the_sbir_program_-_it_is_working.pdf
262 http://www.oecd.org/innovation/policyplatform/48136807.pdf
263 http://preco.share2solve.org/main/reports-and-documents/small-business-research-initiative-sbri-for-procuring-rd-in-the-us-and-the-uk

or service which is taken to market and open to competitive procurement.

Any organisation can submit an application, although it is expected that SBRI opportunities will be particularly attractive for SMEs. The programme provides 100% funding.

At this moment, the evidence suggests that existing attempts are not yet that successful in Europe as in the US not because of the idea itself, but because of the way it is implemented. Rather than implementing similar national schemes in other European countries, a general recommendation here would be to develop ***an integrated European-level SBIR programme with strong coordination mechanisms and competitive budgets.***

The abovementioned needs (i.e., covering the full innovation cycle including closer to market activities, applying a phased approach and developing a European-level programme) are already reflected in a new ***SME instrument*** to be launched under Horizon 2020. The instrument aims to fill the gaps in funding for early-stage, high-risk research and innovation by SMEs, as well as stimulating breakthrough innovations. Support will be provided in three different phases covering the whole innovation cycle (i.e., similar to the US SBIR model). A *feasibility part* will allow an assessment of the technological and commercial potential of a project. A *main grant* will be provided to undertake R&D activities with the emphasis on demonstration and market replication. Finally, the *commercialisation phase* will be supported indirectly through simplified access to debt and equity financial instruments as well as various other measures, for example, on IPR protection. The progress of an SME will be evaluated at the end of each phase. Successful completion of one phase will allow an SME to move on to the next, each phase will be open to all SMEs[264]. The findings of the current study provide additional justification and confirm a clear need for this new instrument.

Some ***specific requirements*** for the European-level SBIR programme include the following:

- consistent multi-year programmatic approach split into *several phases*;
- covering the *whole innovation cycle*, from support to basic research and major research infrastructures to the promotion of open markets for new innovative products, thereby making full use of regulations, standards, public procurement and intellectual property rights (i.e., extending the scope of funding towards closer to market activities);
- applying *no dilution of ownership or repayment required* (i.e., award recipients would retain rights to Intellectual Property developed using the SBIR award, with no royalties owed to the government since this is reported to be one of the key features making SBIR attractive to companies[265]);
- offering *competitive budgets* (comparable to those in the US) with 100% funding;
- applying *strong coordination mechanisms* to minimise the risk of lack of coordination from the policy makers' side (one of the current challenges of national SBIR-type of programmes in the EU);

[264] http://ec.europa.eu/research/horizon2020/pdf/press/fact_sheet_on_sme_measures_in_horizon_2020.pdf
[265] http://www.oecd.org/innovation/policyplatform/48136807.pdf

- *Including entrepreneurs, industry experts, investors, as well as scientists in the evaluation panels*. An additional gain from such an evaluation programme would be the added value that would accrue from the coming together of experts from all over Europe to learn from each other how to evaluate business plans. This would be a continuous learning process that would benefit the EU.

Below we provide a short overview of the current status in different world regions, accompanied by ranking (1 – the best in the sample).

TABLE 4-1: Comparative analysis of measures aiming to stimulate the technology transfer from research organisations to companies: support to young technology companies in a form of funding for the R&D&I activities

| World region | Summary | Ranking |
|---|---|---|
| **TECHNOLOGY TRANSFER FROM RESEARCH ORGANISATIONS TO COMPANIES** | | |
| **Support to young technology companies in a form of funding for R&D&I activities** | | |
| **Europe** | Several relevant initiatives already exist in Europe at both national and EU levels (e.g., the SBRI programme in the UK and the SBIR programme in the Netherlands; FP and CIP programmes at the EU level). However the European equivalents are reported to be less successful for a number of reasons. At the national level, those include lack of leadership and coordination at the government's side, too short time period and too small scale to judge on the impact, and more modest funds than in the United States. The EU-level equivalents are suggested to be of fragmented short-term nature.<br>Within SBRI programme in the UK, 24 million GBP were awarded to 370 R&D contracts from 2008 to 2010[266]. Average size of funded projects is ~65.000 GBP or ~77.500 EUR<br>The annual budget of the Dutch SBIR programme in 2010 was 26.3 million EUR[267]. Average size of funded projects is 100.000 - 500.000 EUR. | **3** |
| **United States** | SBIR programme aims to encourage domestic small businesses to engage in Federal Research/Research and Development (R/R&D) that has the potential for commercialisation. Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialisation. SBIR is suggested to be ***the world's largest seed capital programme for science and technology businesses***. Some of the most innovative US companies have received early stage financing from SBIR, including Apple, Compaq and Intel. A key feature of the programme refers to the absence of a requirement of matching funds from the company's side which is often beyond the means of start-ups and small businesses, i.e., the programme implies 100% funding plus a small profit element.<br>According to the latest data available, through fiscal year 2009, over 112.500 awards have been made, totalling more than 26.9 billion USD[268]. Average size of funded projects is ~239.000 USD or ~179.500 EUR. | **1** |
| **Asia (China)** | No comparable SBIR equivalent was detected in China. Nevertheless, several measures have been introduced there recently to stimulate the technology transfer from universities to companies such as MLP 2006-2020. These measures are reported to have raised the awareness of innovation-oriented public procurement among various stakeholders and have already facilitated commercialisation of several strategic technologies | **4** |
| **Asia (Taiwan)** | Under Taiwan's SBIR plan, SMEs can apply for subsidies covering up to 50% of the total cost of R&D. This government funding support helps to reduce the costs and the level of risk that SMEs must bear when engaging in innovation or R&D. By encouraging SMEs to undertake the development of new industrial technologies and products, the SBIR plan aims to boost overall private-sector R&D spending, speed up industrial upgrading and strengthen Taiwan's international competitiveness.<br>In terms of the total budget and average grant size, the latest available data refers to the | **2** |

[266] http://www.nesta.org.uk/library/documents/Buying_Power_150610.pdf
[267] http://www.agentschapnl.nl/content/sbir-power-public-procurement
[268] http://www.sbir.gov/about/about-sbir

| World region | Summary | Ranking |
|---|---|---|
| | period from 2000 to 2002. The total government subsidy 1.523 million NTD $ or 34.5 million EUR, with 643 phase 1 and phase 2 grants awarded[269]. That makes the average grant size ~54.000 EUR. | |

### *4.1.2. Ensuring uniformity in terms of legal aspects*

A need for uniformity in Europe specifically refers to two legal aspects: (1) general IP system in the EU, and (2) IP management rules for the EU-funded projects. Below we elaborate on each of those aspects in detail.

#### *4.1.2.1. Introducing unitary patent*

***Europe's institutions need to implement uniformity in terms of legal aspects for technology transfer. The rules for EU-funded projects need to take into account the mission and legitimate interests of both public research institutes and participating industrial partners. Examples of possible adjustments refer to mandatory Consortium Agreement templates and an opportunity to work with smaller consortia that are easier to coordinate also from IP perspective.***

The current European patent system, including the phase after granting a patent, is characterised as highly expensive, fragmented and complex. The lack of a unitary patent protection system has so far constituted a market barrier for European entrepreneurs to an effective functioning in both the EU internal market and on the world markets[270]. It is also widely recognised as a hindrance to innovation in Europe[271].

The European Patent Office (EPO) administering 38 countries (EU 27 + 11 other European countries) examines patent applications and is responsible for granting European patents if the relevant conditions are met. However, in the current system, for a granted patent to be effective in a Member State, the inventor has to ***request validation in each country*** where patent protection is sought. This process involves considerable translation and administrative costs***, reaching approximately 32,000 EUR when patent protection is sought in the EU27, of which 23,000 EUR arises from translation fees alone***. In comparison, ***a US patent costs on average 1,850 EUR***[272]. Even lower costs are reported in China and Taiwan. Furthermore, the maintenance of patents in Europe requires the payment of annual renewal fees country by country which implies much higher costs. Similarly, a transfer of the patent or a licensing agreement to use the patented invention has to be registered the same way[273]. These challenges inevitably influence the development of technology transfer also in the semiconductors field.

Consequently, if Europe wants to stay competitive, there is a clear need for a unitary patent system. Unitary patent protection would foster scientific and technological advances and the functioning of the internal market by making access to the patent system easier, less costly and legally secure. It would also improve the level of patent protection by making it possible to obtain uniform patent

[269] http://www.sbir.org.tw
[270] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/134394.pdf
[271] http://ec.europa.eu/unitedkingdom/press/press_releases/2011/pr1138_en.htm
[272] http://ec.europa.eu/unitedkingdom/press/press_releases/2011/pr1138_en.htm
[273] http://ec.europa.eu/unitedkingdom/press/press_releases/2011/pr1138_en.htm

protection in the participating Member States and eliminate costs and complexity for undertakings throughout the Union, especially for SMEs[274].

This recommendation in its essence is not new. The Commission's proposal for a single EU patent has been under discussion for over a decade, and the findings of the current study once again support the need for a change. On 17 December 2012, the Council of the European Union, adopted two regulations with a view to implementing enhanced cooperation in the area of the creation of unitary patent protection (PE-CO_S 72/11) and its translation arrangements (18855/2/11 REV 2)[275]. The two regulations entered into force on 20 January 2013[276]. The new unitary patent aims to radically reduce, by up to 80%, translation and related costs for obtaining patent protection in the EU[277].

Furthermore, on 19 February 2013, an international agreement establishing a Unified Patent Court (UPC) was signed. The agreement aims to lead to the creation of a specialised patent court competent for litigation related to patents granted by the EPO, e.g. classical European Patents as well as future Unitary Patents. Requests for unitary patents may be filed once the legal provisions for both the unitary patent and the UPC have entered into force. However, the regulations will only apply from 1 January 2014 or the date of entry into force of the Agreement on a Unified Patent Court[278].

The findings of the current study provide additional justification and confirm a clear need for this new approach. No comparative tables will be provided in this case as the challenge of a fragmented patent system is unique to Europe.

#### *4.1.2.2. Advancing IP management rules for the EU-funded projects*

Rules for IP management are a fundamental aspect of EU-funded projects, defining the success of dissemination and utilisation activities. It is therefore vital that these rules take into account the mission and legitimate interests of both public research institutes and participating industrial partners. For future European programmes such as Horizon 2020, more clear and streamlined rules for IP and access rights need to be defined, and the necessary measures need to be taken to ensure their implementation. This may be achieved through ***mandatory Consortium Agreement templates*** that may depend on the type of project and the phase of the innovation cycle, with which the participants will be acquainted in advance, and which will avoid spending disproportionate amounts of time and efforts for preparing the Consortium Agreements of EU projects[279]. Additionally, the consortium size is suggested to affect the complexity of IP issues. Smaller consortia are easier to coordinate also from IP perspective, while large consortia inevitably create highly complex IP

[274] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/134394.pdf
[275] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/134394.pdf
[276] http://www.epo.org/news-issues/news/2013/20130219.html
[277] http://ec.europa.eu/commission_2010-2014/barnier/headlines/news/2012/12/20121211-2_en.htm
[278] http://www.epo.org/news-issues/news/2013/20130219.html
[279] See also EC (30/11/2011), *Public Consultation for Horizon 2020*: Written contributions from European organisations received in response to the Green Paper, cross-document analysis of Question 20

agreements and associated disputes. From IP perspective, it would therefore be desirable to ***allow consortia to be compact in size***[280].

## 4.2. Measures to stimulate R&D&I skills

R&D&I is a key driver for an industry that heavily relies on the technological progress. The semiconductor industry needs highly skilled workers in the design and production, workers capable of handling the highly multi-disciplinary nature of the semiconductor industry and KETs in general. ***However, the shortage of sufficient skilled labour remains a major challenge in the EU***. In the area of e-skills alone, for example, the level of computer science graduates is declining, while up to 700.000 ICT practitioners will be needed to fill vacancies in the EU by the year 2015[281]. Europe's shift from heavy industry to more specialised manufacturing and services, combined with generally low prestige for highly technical professions, has outpaced the development of Europe's educational system[282]. Although the challenge of skilled labour shortage is not unique to Europe and it also has to be faced by the US, Taiwan and China, ***different regions of the world are currently at different levels of development with regard to tackling this challenge***.

***Europe needs a set of urgent and effective policy measures to tackle the shortage of skilled labor for the semiconductor industry. Rather than having a few fragmented ad-hoc initiatives.***

***There is a clear need for an integrated and systematic European-level approach aiming to increase the prestige of working in the semiconductor industry; targeting different age groups starting from the early age; supporting close cooperation of policy makers and educators with industry in developing and implementing educational programmes; and incorporating the multi-disciplinary nature of KETs into the school curriculum.***

The ability to provide highly motivated and skilled workers will be key determinant for European policy makers to keep the European semiconductor industry vital and competitive. To achieve it, education authorities in close cooperation with industry need to develop ***policies and programmes that 'sell' micro- and nano-electronics education and careers as being attractive, prestigious and a future "job for life" with both personal and financial reward***.

***An important consideration here should be that critical career decisions are being made already more than a decade before a student enters the workforce***. For example, middle school students must make the decision to take appropriate math and science courses that will prepare them for higher education in science & engineering fields about 14 years before they start working[283]. Consequently, the promotion of micro- and nano-electronics education and careers cannot start early enough. It is crucial to offer children ***early technical education programmes*** that broaden their choice and development opportunities. These

[280] See also PwC's report on "EU budget support for research and innovation" prepared for the Directorate General for Internal Policies of the European Parliament, June 2012, available at http://www.europarl.europa.eu/committees/en/cont/studiesdownload.html?languageDocument=EN&file=74671

[281] http://europa.eu/rapid/press-release_MEMO-12-484_en.htm, IP/12/259 "e-Skills week 2012: There is a job waiting for you"

[282] Dougherty C. (2007) "Some sectors in Europe face a labor shortage", The New York Times, 10 march 2007

[283] http://www.nanokids.rice.edu/emplibrary/NanoKids_Presentation_English.pdf

programmes need to motivate children to want to learn more, transmit the excitement of science investigation and engineering innovation, and provide teachers with the appropriate tools to facilitate the learning process. Other regions of the world have already recognised the importance of such approach. The box below presents some examples of good practices in this field from the US, the initiatives supported by the National Science Foundation.

**nanoZone[284]: educating children about nanotechnology and potential applications**

The nanoZone is both a website and an exhibition at UC Berkeley's Lawrence Hall of Science (US). The exhibition introduces basic nanoscale and state-of-the-art nanotechnology science to an 8 to 14-year-old audience. Content focuses on the smallness of a nanometer, scientists as people, applications, and links between nanotechnology and nature. Nanozone educates visitors about the top scientists in the field by making their work accessible in ways kids can understand. Visitors are offered hands-on exhibits, computer interactive, live demonstrations, informational videos, animations and other facilitated activities. The project has been realised with the help of a grant from the National Science Foundation (NSF)[285].

Other similar initiatives supported by the NSF include[286]:

- National Nanotechnology Infrastructure Network kid web magazine, Cornell University: Nanooze;
- University of North Carolina: The Remote Nanomanipulator;
- University of Wisconsin: Nanoworld for Kids;
- Book: Exploring the Nanoworld, by G.C. Lisensky et. al.;
- K-12 Education at the Nanobiotechnology Center, Cornell University;
- Cornell University: It's a Nanoworld;
- Cornell University: Center for Nanoscale Systems Institute for Physics Teachers (CIPT);
- Rice University: NanoKids;
- Nanoscale Center for Learning and Teaching;
- Northwestern University: Materials World Modules.

The abovementioned initiatives are linked to a broader strategic framework aiming to support the development of nanotechnology in the US, i.e., the National Nanotechnology Initiative (NII)[287]. Some other NNI initiatives[288] not detailed in this report but discovered during the study include a programme to learn about nanotechnology for kids by playing with Legos®; NanoDays, a nationwide nanotechnology festival; NanoExpress, a "mobile science theme park" travelling throughout the US etc.

**US National Nanotechnology Initiative (NNI)[289]**

Launched in 2000 with eight agencies, the NNI today consists of the individual and cooperative nanotechnology-related activities of 26 Federal agencies with a range of research and regulatory roles and responsibilities. Fifteen of the participating agencies have research and development (R&D) budgets that relate to nanotechnology, with the reported NNI budget representing the collective sum of these investments. Funding support for nanotechnology R&D stems directly from NNI member agencies, not the NNI. As an interagency effort, the NNI informs and influences the Federal budget and planning processes through its member agencies and through the National Science and Technology Council (NSTC). The NNI brings together the expertise needed to advance the nanotechnology field—creating a framework for shared goals, priorities, and strategies that helps each participating Federal agency leverage the resources of all

[284] http://www.nanozone.org/
[285] http://www.exhibitfiles.org/nanozone
[286] For more information see http://www.nsf.gov/crssprgm/nano/education/kids.jsp
[287] http://www.nano.gov/about-nni/what
[288] http://www.nano.gov/education-training/k12
[289] http://www.nano.gov/about-nni/what

participating agencies. With the support of the NNI, nanotechnology R&D is taking place in academic, government, and industry laboratories across the United States. The 2013 Federal Budget provides 1.8 billion USD for the National Nanotechnology Initiative (NNI), reflecting steady growth in the NNI investment.

Below we list some relevant US educational initiatives for higher age students.

**US Albany State University, College of Nanoscale Science & Engineering (CNSE): the world's first college to offer comprehensive baccalaureate programs in Nanoscale Engineering and Nanoscale Science**[290]

With more than 14 billion USD in public and private investments, and the participation of more than 2,600 scientists, researchers, engineers, faculty, and graduate students from leading global corporations and top research universities, CNSE aims to offer ***undergraduate students*** a world-class experience working with, and learning from, the top innovative minds in ***the academic and industrial worlds***.

Both the bachelor's degree in nanoscale engineering and the bachelor's degree in nanoscale science offer an academically rigorous preparation for students intending to pursue scientific, technical, or professional careers in nanotechnology-enabled fields or graduate studies in nanoscale engineering or nanoscale science, as well as other interdisciplinary sciences such as materials science, physics, biophysics, chemistry or biochemistry.

The importance of these programs is captured in the multi-billion dollar ***National Nanotechnology Initiative***, signed into law by the US President in 2004, which calls for the creation of the "laboratory and human resource infrastructure in universities and in the education of nanotechnology professionals" to prepare the US workforce for the 21st century innovation economy.

**US Hudson Valley Community College's TEC-SMART facility (Training and Education Center for Semiconductor Manufacturing and Alternative and Renewable Technologies)**[291]

The facility, opened in January 2010 in Malta, NY, features ***more than a dozen state-of-the-art classrooms and laboratories to train the workforce in semiconductor manufacturing green technologies***, including photovoltaic, home energy efficiency, geothermal, alternative fuels and wind energy. In addition, courses in Business and the Liberal Arts and Sciences area, including English, psychology, math and more are offered.

TEC-SMART was a joint initiative between Hudson Valley Community College and the New York State Energy Research and Development Authority (NYSERDA). The training facility is located at the Saratoga Technology and Energy Park® (STEP®), which is next to the Luther Forest Technology Campus, a 1,350-acre campus designed for nanotechnology manufacturing and research and development. TEC-SMART aims to provide skilled technicians for these plants as well as the growing renewable energies field, helping to accelerate the economic growth of both industries by providing the trained workers they require.

**US Hudson Valley Community College's Semiconductor Manufacturing Technology program (SMT program)**[292]

The SMT program prepares students for careers in the semiconductor manufacturing industry. The training provided is field oriented and generally covers the principles and practices that apply to industry applications of electricity and semiconductor manufacturing. Upon graduation, students are prepared to work in capacity field service, test, and manufacturing, or may transfer to a baccalaureate program.

[290] http://cnse.albany.edu/PioneeringAcademics/UndergraduatePrograms.aspx
[291] https://www.hvcc.edu/tecsmart/
[292] http://www.albany.edu/outreach/SMT_program.php

As mentioned above, industry can and should play an important role in co-developing the relevant educational initiatives. Examples of good practices from other regions of the world refer to the initiatives supported by SIA (US Semiconductor Industry Association). Besides the initiatives listed in the box below, SIA has also actively worked with other organisations to support programs and policies aiming at future generations, and specifically to improve science, technology, engineering and mathematics (STEM) education at the K-12[293] and undergraduate levels[294].

**US SEMI Workforce Development Institute for Teachers[295]**

From 2003 to 2007, the SIA has partnered with the Semiconductor Equipment and Materials International (SEMI) to sponsor SEMI High Tech U programs for high school teachers. The High Tech U Teacher edition was a two-day ***professional development program designed to increase teacher awareness of career opportunities in high tech fields***, while equipping them with math and science based learning activities, with learning activities designed for easy integration into the classroom and support state education standards.

**Maricopa Advanced Technology Education Center (MATEC)[296]**

The SIA works closely with the Maricopa Advanced Technology Education Center (MATEC) in Chandler, Arizona, to provide ***curriculum and faculty training and development for automated manufacturing programs at over 100 two and four-year institutions across the United States***. The National Science Foundation has been a major sponsor of MATEC since it was founded in 1996. MATEC has developed over 50 curriculum modules on all aspects of semiconductor manufacturing. Through representation on the MATEC Advisory Board, SIA has a strong voice in a national program to advance highly automated manufacturing technician education.

**Semiconductor Research Corporation Education Programs[297]**

SIA has partnered with the Education Alliance of its affiliate organisation, the Semiconductor Research Corporation (SRC), on various education initiatives. SRC offers doctoral fellowships and master's scholarships in disciplines of interest to the semiconductor industry. SRC's Graduate Fellowship Program ***addresses the issues of improving educational opportunities at the doctoral level, while also helping fuel a well trained work force for the semiconductor industry***. The program encourages gifted US and Canadian students to pursue doctoral degrees in research areas consistent with SRC goals. The SIA and SRC have also partnered on university ***chip design contests*** to provide an opportunity for students to turn their design concepts into working silicon devices.

However, there is not only a need to promote micro- and nano-electronics education and careers as being attractive, it is also important to increase the awareness and attract students to a wide range of technological disciplines, as micro- and nano-electronics should not be considered in isolation in the context of education. The programmes offered by universities should be adapted to the needs of the industry to foster highly-skilled human capital.

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[293] K-12 is a designation for the sum of primary and secondary education in the United States

[294] SIA Report "Educating Tomorrow's Workforce: The US Semiconductor Industry's Commitment to K-12 Science, Technology, Engineering and Math Education", January 2011

[295] SIA Report "Educating Tomorrow's Workforce: The US Semiconductor Industry's Commitment to K-12 Science, Technology, Engineering and Math Education", January 2011

[296] SIA Report "Educating Tomorrow's Workforce: The US Semiconductor Industry's Commitment to K-12 Science, Technology, Engineering and Math Education", January 2011

[297] SIA Report "Educating Tomorrow's Workforce: The US Semiconductor Industry's Commitment to K-12 Science, Technology, Engineering and Math Education", January 2011

**US Next Generation Science Standards 2013**[298]

Currently, new K–12[299] science standards are being developed in the United States that will be arranged in a coherent manner across disciplines and grades with the aim to provide all students an internationally benchmarked science education. These Next Generation Science Standards (NGSS) are expected to be adopted in 2013 in 26 states. For the first time, science standards will incorporate principles of engineering education and engineering design[300].

The NGSS are intended to reflect a new vision for American science education.

A significant difference in the NGSS is the integration of engineering and technology into the structure of science education by raising engineering design to the same level as scientific inquiry in classroom instruction when teaching science disciplines at all levels, and by giving core ideas of engineering and technology the same status as those in other major science disciplines. ***Such approach aims to motivate many students to continue or initiate their study of science and engineering***. Additionally, the approach aims to empower students to use what they learn in their everyday lives.

Similar initiatives have also been launched in Taiwan. This country is reported to be actively investing in the development of their micro- and nanoelectronics workforce. Teaching children about nanotechnology is reported to be part of standard curriculums.

**Taiwan National Nanotechnology Program (NNP)**[301]

After a few years of detailed study of the US NNI and a thorough investigation and assessment of its own nanotechnology development status, the Taiwanese government launched the Taiwan National Nanotechnology Program (NNP) in 2002 and committed 630 million USD over 6 years (2003 – 2008) to strategically invest in nanoscience and technology R&D by academia and industry, as well as in infrastructure and training of the future nanotechnology workforce in Taiwan and international collaborations. The NNP integrates all related ministries including the Ministry of Economic Affairs (MOEA), National Science Council (NSC), Ministry of Education (MOE), Atomic Energy Council (AEC), Department of Health, and Environmental Protection Administration (EPA). MOE invested 8 million USD ***specifically dedicated to education and training of the Taiwan nanotech workforce.***

Since 2003, Taiwanese government conducted the "Nanotechnology human resource development program" (NHRD)[302]. The NHRD included K-12 Nanotechnology Program and Higher Education Nanotechnology Program, which was established to prepare a future generation of researchers, engineers, designers, and business leaders for the growing micro- and nanoelectronics sector. The key tasks included establishing nanotechnology-interdisciplinary curriculum programs, conducting equipment operation and teacher training, hosting conferences and contests, and setting up international exchange programs[303].

[298] http://www.nextgenscience.org/
[299] K-12 is a designation for the sum of primary and secondary education in the United States
[300] http://www.asee.org/conferences-and-events/conferences/k-12-workshop/2013
[301] http://www.nanoworld.jp/apnw/articles/library2/pdf/2-36.pdf
[302] Meng-Kao Yeh et al. (2011) "Problem-Based Learning Achievement of K-12 Students Participating in a Nanotechnology Hands-on Works Exhibition in Taiwan", International Journal for Cross-Disciplinary Subjects in Education (IJCDSE), Volume 2, Issue 3, September 2011
[303] http://english.moe.gov.tw/ct.asp?ctNode=513&mp=1&xItem=7170

**Taiwan Nanotechnology Human Resource Development Program (NHRD)**[304]

***2003:*** The Nanotechnology Human Resource Development Program (NHRD) was officially launched, with five Regional Education Centres set up to run the program. The K-12 Nanotechnology Program and the Higher Education Nanotechnology Program were also set up as part of the NHRD.

***2004***: With the aim of laying the groundwork for the development of nanoscience and nanotechnology in Taiwan, the Ministry of Education's Advisory Office set up ***the National Office for Promoting the Nanotechnology Human Resource Development Program*** and established a network of digital learning platforms. The Taiwan Science Education Center, the National Museum of Natural Sciences and the National Science and Technology Museum became working partners in the program.

***2005***: ***More than 1,000 first generation nanoscience and nanotechnology teachers completed their initial training programs***. Several multimedia educational materials were published, including comics, CDs and interactive software.

***2006***: ***Masters Degrees in nanotechnology-related disciplines were set up*** in partnership with industrial enterprises. New initiatives to further promote nanoscience and nanotechnology included ***school science camps, teacher workshops and the development of online learning resources***. Teachers from across Taiwan attended the K-12 Nanoscience and Nanotechnology Teachers Conference.

***2007***: A wide range of new educational materials were published.

***2008***: ***The teaching of nanotechnology no longer sat on the periphery of science education and became fully integrated in the national curriculum***. Regional Education Development Centers designed courses suitable for high school students and worked with higher education institutions to offer interdisciplinary courses with distance learning and online tutorials available to students.

***2009***: The National Science Council's Department of Science Education launched Phase 2 of the Nanotechnology Human Resource Development Program. This continued and expanded on the work of Phase 1, with courses in nanoscience and nanotechnology revised and adapted based on research into the success or otherwise of fledgling courses. 2009 also saw the opening of the Center for Nanoscience and Nanotechnology Teaching Knowledge and Understanding.

***2010***: the HNRD program, now well into Phase 2, led to the development of clear teaching strategies and the provision of quality teaching materials. A wide range of hands-on educational experiences in the nano field have been established to help popularise and enrich students' learning experiences.

When compared with the educational and promotional programmes in the US and Taiwan, ***Europe is currently catching up, not leading***. Additionally, ***the level of development of micro- and nano-electronics educational programmes for different age groups considerably varies within the EU***. Among the European countries, the leading role in this respect is assigned to Great Britain, France and Germany[305], and particularly when looking at the number of majors connected with nanotechnology offered at master's and doctoral studies or the offer of the relevant master's studies. In the box below we list a number of examples of European level initiatives indirectly related to the promotion of micro- and nanoelectronics education and career.

[304] http://nano.narl.org.tw/201204/e.html
[305] Poteralska B., Zielinska J. (2007) "The Development of Education and Training Systems in the Field of Nanotechnology", Journal of College Teaching & Learning – June 2007, Volume 4 Number 6

**NANOYOU project**[306]

NANOYOU (Nano for Youth) was a project funded by the European Commission's Seventh Framework Programme that aims to increase young people's basic understanding of nanotechnologies and to engage in the dialogue about its ethical, legal and social aspects (ELSA). The total project budget comprises 1.655 million EUR, of which 1.453 million EUR refers to the EU support[307].

The project's target audience is composed of young people in the 11-25 age group. At least 400 schools are expected to participate, with programmes reaching more than 25,000 students in more than 20 countries. The science centres programme is expected to reach an initial 4,000 young adults, followed by many more as more science centres adopt the programme.

Activities and materials include:

- Video and posters with information about nanoscience and nanotechnologies and their fields of application;
- Online animations, simulations and virtual experiments based on current research;
- NTs time machine game inviting students to travel through human needs, looking at past, present and possible future solutions;
- "What are nanotechnologies?" workshop, where nanotechnologies will be introduced through games such as a nano-memory game and nano-jigsaw puzzle;
- A role play workshop that will present dilemmas where students will choose different stakeholder roles;
- Virtual dialogues that will enhance students' discussion on different nanotechnologies topics and will allow them to communicate with each other through a forum on the project website.

**Time for Nano Project**[308]

The Time for Nano Project aims at engaging the general public, with a special attention to young people, on benefits and risks related to nanoscale research, engineering and technology, through specific informal education products. Science centers in Italy, UK, Belgium, France, Germany, Finland, Portugal, Poland and Turkey organise "Nanodays", events with demonstrations, experiments, games, meetings and discussions about nanotechnology. The total project budget comprises 1.646 million EUR, of which 1.474 million EUR refers to the EU support[309].

The need to continue investing in such initiatives is acknowledged in the future EU programmes. Under Horizon 2020, the Commission aims to continue and reinforce actions to attract young people to KETs and include training activities aimed at improving skills in KETs product demonstration projects. Examples of such measures refer to developing partnerships between education and business such as Knowledge Alliances for Higher Education in order to foster innovation and allow for more targeted curricula with regard to market needs including KETs[310].

In the meantime, in the face of considerable skill shortages, many companies are currently taking the initiative in their own hands and are reaching out to universities, technical colleges and even secondary schools to communicate to young people about the technology and future career opportunities. Other more short-term solutions include recruiting people from outside Europe, but those solutions are often challenged by bureaucratic hurdles related to work permits and the need

306 http://nanoyou.eu/

307 http://www.nmpteam.eu/eu-project/nanoyou/c810e3a0-05f4-4be2-8bf7-f6a98fda4fda

308 http://www.timefornano.eu/

309 http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RCN=10616961

310 http://europa.eu/rapid/press-release_MEMO-12-484_en.htm, IP/12/259 "e-Skills week 2012: There is a job waiting for you"

for foreign employees to be able to speak European languages other than English (e.g., German, French). The latter is often needed, among others, to communicate with the local employees they supervise/report to.

To summarise, Europe needs a set of urgent and effective policy measures to tackle the shortage of skilled labor for the semiconductor industry. Rather than having a few fragmented ad-hoc initiatives, there is a clear need for an integrated and systematic European-level approach. Based on the lessons learned from other world regions, some key features of such measures should include the following:

- ***Aiming to increase the prestige of working in the semiconductor industry***: educators and policy makers need to develop programmes that 'sell' micro- and nano-electronics education and careers as being attractive, prestigious and a future "job for life" with both personal and financial reward.

- ***Developing highly specialised educational programmes***: such programmes need to be offered at the universities in close proximity to the European semiconductor clusters.

- ***Targeting different age groups starting from the early age***: offering children early technical education programmes that broaden their choice and development opportunities. These programmes need to motivate children to want to learn more, transmit the excitement of science investigation and engineering innovation, and provide teachers with the appropriate tools to facilitate the learning process.

- ***Close cooperation of policy makers and educators with industry in developing and implementing educational programmes***: adjusting the curriculum to the actual industry needs; developing students' ability to apply content knowledge to practice thereby focusing on understanding and application as opposed to memorisation of facts isolated from the context; involving students in industry activities (e.g., field visits, traineeships, workshops, case studies etc.).

- ***Incorporating the multi-disciplinary nature of KETs into the school curriculum***: training students to apply and merge knowledge from various disciplines, stimulate students to work on various applications by means of interconnecting what they have learned throughout the whole learning period.

TABLE 4-2: Comparative analysis of R&D&I policies: measures to provide the semiconductor industry with highly motivated and skilled workers

| World region | Summary | Ranking |
|---|---|---|
| **R&D&I POLICIES** | | |
| **Measures to provide the semiconductor industry with highly motivated and skilled workers** | | |
| **Europe** | The level of development of micro- and nano-electronics educational programmes for different age groups considerably varies within the EU. Among the European countries, the leading role in this respect is assigned to Great Britain, France and Germany, and particularly when looking at the number of majors connected with nanotechnology offered at master's and doctoral studies or the offer of the relevant master's studies. In the face of considerable skill shortages, many companies are currently taking the initiative in own hands and are reaching out to universities, technical colleges and even secondary schools to communicate to young people about the technology and future career opportunities. These are fragmented ad-hoc initiatives; there is currently hardly an integrated and systematic European-level approach. | 3 |

| World region | Summary | Ranking |
|---|---|---|
| **United States** | Tackling a skilled labour shortage is a national priority. A broad set of measures has been introduced since early 2000s, embedded in a strategic framework aiming to support the development of nanotechnology in the US, i.e., the National Nanotechnology Initiative (NII). Industry plays an important role in co-developing the relevant educational initiatives. SIA has actively worked with other organisations to support programs and policies aiming at future generations, and specifically to improve science, technology, engineering and mathematics (STEM) education at the K-12 and undergraduate levels. Finally, the Next Generation Science Standards are expected to be adopted in 2013. A significant difference in the standards is the integration of engineering and technology into the structure of science education by giving core ideas of engineering and technology the same status as those in other major science disciplines. Such approach aims to motivate many students to continue or initiate their study of science and engineering. Additionally, the approach aims to empower students to use what they learn in their everyday lives. | **1** |
| **Asia (China)** | The education for nanotechnology in China mainly focuses on graduate education based on the research activities in the universities and research centres. Currently, undergraduate programs are available for materials science, microelectronics, etc., but not for nanotechnology/nanoelectronics. | **4** |
| **Asia (Taiwan)** | Tackling a skilled labour shortage, and particularly in the semiconductor industry, is a national priority. Developing appropriate instructional modules of nanotechnology have become an attractive and important issue in schools in Taiwan. Young kids are offered games, exhibitions and integrated courses. Secondary school students are provided with more complex instructional materials. Since 2003, Taiwanese government conducted the "Nanotechnology human resource development program" (NHRD)[311]. The NHRD included K-12 Nanotechnology Program and Higher Education Nanotechnology Program, which was established to prepare a future generation of researchers, engineers, designers, and business leaders. Tasks included establishing Nanotechnology-interdisciplinary curriculum programs, conducting equipment operation and teacher training, hosting conferences and contests, and setting up international exchange programs[312]. | **2** |

## 4.3. *Tax incentives*

Although Europe in general already has quite competitive tax policies in place, the analysis in Section 3.1.2 revealed that companies located in East Asia enjoy a more favourable tax climate. Specific recommendations to improve the attractiveness of the European tax climate for the semiconductor companies include the following: (1) R&D tax incentives need to be introduced to regions that currently do not have those in place; (2) R&D tax incentives need to be expanded with the aim to level the effective tax rates for R&D with the "best-in-class" region; and (3) innovation-friendly tax incentives need to be further explored as an alternative to tax holidays. Below we first elaborate on the number of tax incentives with respect to the corporate income tax rates. We then move on to addressing each of the recommendations in more detail.

### *4.3.1. Corporate income tax rates and tax incentives*

Corporate income tax (CIT) is one of the fundamental factors of tax policy to which tax incentives directly relate. It is therefore crucial to keep in mind the CIT rates when reviewing the various tax incentives in place.

[311] Meng-Kao Yeh et al. (2011) "Problem-Based Learning Achievement of K-12 Students Participating in a Nanotechnology Hands-on Works Exhibition in Taiwan", International Journal for Cross-Disciplinary Subjects in Education (IJCDSE), Volume 2, Issue 3, September 2011

[312] http://english.moe.gov.tw/ct.asp?ctNode=513&mp=1&xItem=7170

In general, high tax incentives may coincide with high corporate tax rates, or vice versa. Comparatively high CIT rates are disadvantageous for companies that are affected by these rates. To offset the disadvantage, high tax incentives are sometimes offered as compensation. The other way around, regions that have low CIT rates in place, may choose to have less favourable tax incentives in place. This is also referred to as creating a *selective balance* in the tax system.

Table 4-3 provides a brief overview of the CIT rates and the available tax incentives for the analysed regions. Furthermore, each region is ranked according to how favourable the overall tax conditions in the area are. This is based both on the available tax incentives and the CIT rates that apply.

TABLE 4-3: Comparison of CIT rates and tax incentives across the regions

| World region | CIT (%) | Tax incentives | Rank |
|---|---|---|---|
| **Tax incentives** | | | |
| **European regions** | | | |
| Belgium | 33.99% (33% + 3% crisis surtax) | • Tax deduction for income derived from patents (Patent Income Deduction);<br>• Tax deduction for R&D investments (15.5% one off tax deduction on R&D-investments listed on the balance sheet or 22.5% depreciation of those investments);<br>• R&D tax credits (alternative for tax deduction on R&D investments; a company may opt for tax credits equal to the amount that is eligible for R&D tax deduction, spread out over 5 years). | **2** |
| France | 34.43% (33.33% + 3.3% surcharge) | • R&D tax credits (30% of R&D expenses + 5% beyond 100M EUR)[313]<br>• Tax exemption and deferral for Young Innovative Enterprises ("Jeune Entreprises Innovantes"). | |
| Germany | ~29.48%[314] | • No R&D tax incentives are offered in Germany. | |
| The Netherlands | 20-25% | • Reduced tax rate for revenues from patents and/or qualified innovation ("Innovation box");<br>• R&D wage tax credit ("WBSO");<br>• Research and Development Allowance (RDA) – 140% non-wage expense super deduction (one-off). | |
| United Kingdom | 24% | • Tax deduction for R&D;<br>• Reduced tax rate for revenues from patents and other innovations ("Patent Box"). | |
| **United States** | | | |
| **United States** | 15-35% (39.2% when both federal and state level taxes are applied) | • R&D tax credits (lapsed; 20% traditional, 14% Alternative Simplified Credit). | **3** |
| **Asia** | | | |
| **China** | 25% | • Tax holidays (2 year exemption followed by a 3 year 50% reduction of CIT);<br>• Reduced tax rate (15%);<br>• Accelerated depreciation of equipment. | **1** |
| **Taiwan** | 17% | • R&D credits (max. 30% of tax payable, 15% of R&D expenses);<br>• Tax holidays (5 years). | |

[313] This rate is increased to 40% and 35% for the first and the second year, respectively, during which the company incurs eligible R&D expenses, or after the expiration of a period of five consecutive years during which the company did not benefit from the tax credit.
[314] The effective tax rate is composed of a 15% base tax + 5.5% solidarity surcharge and an additional trade tax that varies between 7-17.15%. For more details, see: http://www.kpmg.com/global/en/services/tax/tax-tools-and-resources/pages/corporate-tax-rates-table.aspx

When comparing the CIT rates among the regions, East Asia clearly offers the lowest corporate tax rates in the sample. Taiwan's corporate tax rate is among the lowest rates in the world. While China has a medium level corporate tax rate in place, it should be noted that the vast majority of the semiconductor companies enjoy the reduced tax rate of 15%. Low corporate tax rates also extend to other semiconductor hotspots in Asia. In Singapore, for example, the CIT rate equals 17%. Moreover, companies there may benefit from a concessionary tax rate of 15% for up to 5 years[315].

**Tax incentives in Singapore**

Singapore's tax incentives are not unique to the semiconductor industry. Instead they are targeted to industries that are regarded as being key to Singapore's competitiveness. The semiconductor industry is one of the key strategic industries for Singapore. Moreover, CIT rates are low in Singapore (17%), with the possibility to obtain a reduced tax rate of 15% for up to 5 years. Two relevant tax incentive programmes were identified:

**1. Headquarters Program - Regional Headquarters Award**

The Headquarters Program offers a concessionary tax rate of 15% for 3+2 years on incremental qualifying income from abroad. If the applicant company satisfies all the minimum requirements by Year 3 of the incentive period, it will enjoy a 15% concessionary tax rate for an additional 2 years on qualifying income.

**2. SME Cash Grant and Corporate Income Tax (CIT) Rebate**

This tax incentive programme specifically targets SMEs. For 2012, companies can be granted a one-off 5% SME Cash Grant. For 2011, companies can be granted a 20% CIT Rebate or a 5% SME Cash Grant, whichever is the higher amount.

Within Europe, large differences in corporate tax rates can be observed. On the one hand, the Netherlands and the United Kingdom have relatively low corporate tax rates in place, ranging between 20 to 25%. On the other hand, the Belgian and French fiscal authorities respectively tax 33.99% and 34.43% on corporate income. More importantly, the CIT rates in the European clusters are higher than in their Asian counterparts by a considerable margin. The United States is at a comparative disadvantage here having the highest CIT rate in place in the sample.

In terms of R&D tax incentives, Europe showcases a number of strong instruments. Many European countries offer tax relief for R&D activities in the form of R&D tax credits or through reduced tax rates on profits from patents or innovation. France in particular offers highly favourable tax incentives, especially for SMEs. The R&D tax credits in France are among the highest credits in the sample. At the same time, the corporate tax rate in France is high, implying that the higher corporate tax in France is partly compensated by an attractive tax incentive scheme. Conversely, Germany has a lower corporate tax rate but offers no R&D tax incentives at all.

***The aggressive tax policies in the East Asian countries, however, cannot be matched with Europe's current R&D tax incentives***. Favourable tax holidays, reduced tax rates and accelerated depreciations offer clear benefits for companies located in those respective regions. Moreover, these policies are paired with an already low CIT rate, which further enhances the tax position of the East Asian countries.

Finally, the United States is at the other end of the spectrum. A high corporate income tax coupled with weak tax incentives, puts the region at a considerable disadvantage. Moreover, the only instrument in place, the R&D tax credit, is not permanent and has already lapsed. The R&D tax credit, even if it were reinstated, is also comparatively weak; at its current rate of 14-20%, it is situated at

[315] http://www.edb.gov.sg/content/edb/en/why-singapore/ready-to-invest/setting-up/taxation.html

the lower end of the spectrum in the sample. The R&D tax credits can therefore not completely offset the comparative disadvantage the United States are facing.

**The impact of US tax policy on the costs of semiconductor manufacturing**[316]

To assess the impact of tax policy on the competitiveness of the semiconductor industry in the US, SIA calculated how much it would cost to build and operate a 300mm wafer fabrication facility. Over a ten year period, this would cost 6.7-6.8 billion USD in the US, compared to 5.6-6.1 billion USD outside the US In other words, there is a difference of up to 1.1 billion USD in costs. Breaking down these costs, about 70 percent of the difference is due to tax benefits, 20 percent due to capital grants, and only 10 percent due to lower labor and other operating costs, such as lower utility costs or cheaper logistics. Despite the considerable tax disadvantages, the state of New York has taken much effort to provide competitive benefit packages for the semiconductor industry. To attract GLOBALFOUNDRIES to Tech Valley, they tried to mitigate the difference in costs with an incentive package that included both a cash grant and tax incentives. The specifics of the tax incentives, however, were never publically made available, although it is said that approximately 750 million USD in tax benefits was negotiated[317].

In order for European semiconductor industry to be competitive, it is of high importance to narrow the competitive gap in tax policy between Europe and East Asia. Harmonising the CIT rates with the Asian countries would be one way to do it, but this has strong consequences for the budgets of the individual Member States. Other option could be to focus specifically on R&D tax incentives. More specifically, Europe should narrow the gap by:

- introducing R&D tax incentives to regions that currently do not have them in place;
- expanding R&D tax incentives with the aim to level the effective tax rates for R&D with the "best-in-class" region;
- further exploring innovation-friendly tax incentives.

Below these recommendations will be discussed in more detail.

### *4.3.2. Introducing R&D tax incentives to regions that currently do not have these in place*

***R&D tax incentives need to be introduced in European regions that currently do not have such incentives in place. Tax incentives can both offset a comparative disadvantage in corporate tax rates and attract semiconductor companies with additional benefits.***

R&D tax incentives were found to be a vital instrument for boosting the competitiveness of the semiconductor industry. Tax incentives can both offset a comparative disadvantage in corporate tax rates and attract semiconductor companies with additional benefits. Tech Valley (Albany, United States) is a case in point, as the State of New York offered considerable benefits to GLOBALFOUNDRIES to offset the unattractive tax policy in the region.

R&D tax incentives are in place in most of the analysed European clusters. Nonetheless, some European regions, like Germany in our sample, do not offer such incentives at the moment. OECD (2010)

[316] SIA, (2009). "The Semiconductor Industry Association's Comments to the President's Economic Recovery Advisory Board's Tax Reform Subcommittee", San Jose, California.
[317] Times Union (2011). "$650M still an orphan", available at http://www.timesunion.com/business/article/650M-still-an-orphan-2220786.php

argues that for Germany specifically, ***the introduction of tax incentives for R&D is long overdue***[318]. With an average corporate tax rate of 29.48% and no tax incentives to compensate for this, Germany is lagging behind the East Asian countries.

Newly introduced R&D tax incentives need to focus on closing the gap between Europe and East Asia. Particularly, such tax incentives should aim to offset the comparative disadvantage of Europe to Asia when it comes to taxes for R&D. The low CIT rates in East Asia are challenging to offset, but introducing, for instance, R&D tax credits that compensate for a large part of the gap may provide a solution.

### 4.3.3. Expanding R&D tax incentives to level the effective tax rates for R&D with the "best-in-class" region.

Europe needs to ***expand its R&D tax incentives to level the effective corporate tax rates for specifically R&D activities with the "best-in-class" region***. While CIT rates vary within Europe, none of the included European regions can currently compete with the low CIT rates in East Asia. Corporate taxes comprise the starting point of tax policy. The volume of the various tax incentives is only as relevant if the corporate taxes are explicitly considered. For instance, France offers the strongest R&D tax credits in the sample. However, companies located in China, Taiwan or Singapore are still better off in terms of tax policy simply because of the substantial differences in CIT rates and the additional tax benefits.

***Existing R&D tax incentives need to be expanded to level the effective corporate tax rates for R&D related activities with the "best-in-class" region. That would help Europe to compete with aggressive Asian tax policies.***

Although the aggressive tax policies in East Asia are difficult to match, ***Europe already has a number of building blocks to work with***. R&D tax incentives in France, specifically the R&D tax credits, greatly reduce the tax burden for companies performing R&D. Moreover, super deductions in Belgium, the Netherlands and the United Kingdom lower the tax burden for R&D expenses specifically. In the case of the United Kingdom, these deductions are also uncapped for large companies[319]. Another important mechanism to consider is innovation-friendly tax incentives, which are discussed in more detail in the following sub-section.

### 4.3.4. Further exploring innovation-friendly tax incentives

Tax holidays and tax deductions comprise the key elements of the aggressive tax policies in the East Asian countries. Semiconductor companies often qualify in these countries to be exempted from tax for 2-5 years or to enjoy reduced corporate tax rates. Combined with a comparative advantage in CIT rates in those countries, Europe needs to react to narrow the gap in tax regimes.

Tax holidays of the sort used in the East Asian countries, however, are currently not allowed in Europe. In response, experts have suggested that the EU and its Member States need to consider the benefits from tax deferrals and other tax incentive packages, claiming that this would help create a

[318] "Roadmap to a Resource Efficient Europe", VCI, 2012 available at: https://www.vci.de/Downloads/111123%20VCI%20Position%20on%20the%20roadmap%20to%20a%20resource%20efficient%20Europe_final.pdf

[319] Deloitte (2012). "2012 Global Survey of R&D Tax Incentives".

***Innovation-friendly tax incentives should be further explored as an alternative to aggressive tax holidays found in particularly the East Asian countries. One possible suggestion is to experiment with tax deductions, tax exemptions and tax deferrals that are directly linked to R&D activities.***

global level playing field[320]. Such tax incentive packages, however, need to be compatible with European regulation. ***Innovation-friendly tax incentives, which are directly linked to R&D activities, should therefore be further explored***.

Some European countries have already started experimenting with innovation-friendly tax incentives. The "Innovation Box" has been in place in the Netherlands since 2010. The ruling allows companies to deduct the development costs and losses on the exploitation of IP that qualifies against the 25% tax rate. It reduces the effective tax rate for income derived from such IP to 5%[321].

In Belgium, companies can benefit from the Patent Income Deduction (PID). This ruling allows companies to deduct up to 80% of the income from qualified patents from their taxable income. For these activities, this results in a 6.8% effective tax rate[322].

In the United Kingdom, the Patent Box will come into effect on April 1, 2013. The ruling reduces the corporate tax rate on profits earned after April 1, 2013 from its patented inventions and certain other innovations. The reduced corporate taxes will be phased in from April 1, 2013 and initially sets the reduced corporate tax rate for this specific type of income to 10%[323].

The French authorities have a special tax relief programme for Young Innovative Enterprises, called "Jeune Entreprises Innovantes" (JEI). The firms that can benefit from JEI are SMEs which are less than 8 years old, however only as long as they meet the following five criteria: it must be an SME as defined by the EU, young, independent, and genuinely new, with research and development costs being at least 15% of its expenses. It implies full tax exemption for the first 3 profitable fiscal years followed by 50% relief for the next 2 profitable years, full exemption from the Annual Minimum Tax and 7 years exemption from local business tax and/or property tax. The company also gets an exemption for employers' contributions for maximum 8 years, for employees involved in research activities.

Tax incentives like these clearly help reduce the tax burden for companies undertaking R&D. They have, however, only been into place for a relatively short period of time. It is therefore too early to fully evaluate their effects. While not as comprehensive as the tax holidays in the East Asian countries, innovation-friendly tax incentives are consistent with the EU regulation. This means that they can be implemented relatively easily across the board. Member States therefore should further develop and implement such incentives to offer an alternative for the tax holidays offered in East Asia. Moreover, the benefits need to be carefully evaluated to ensure that these programmes can provide a viable alternative to the tax holidays and exemptions in East Asia.

[320] European Commission (2012), "The role of Taxation, IPR and State Aid in EU ICT competitiveness: Report of a High-Level Panel Discussion", DG Connect, Brussels.
[321] Deloitte (2012). "2012 Global Survey of R&D Tax Incentives".
[322] Deloitte (2012). "2012 Global Survey of R&D Tax Incentives".
[323] Deloitte (2012). "2012 Global Survey of R&D Tax Incentives".

## 4.4. Innovation and industrial policy regimes

Two main aspects requiring attention with regard to innovation and policy regimes refer to (1) the role of large companies in the semiconductor clusters, and (2) the need to keep manufacturing in Europe. Both aspects are closely interrelated, and we elaborate on each of them below.

#### 4.4.1.1. Role of large semiconductor companies in regional clusters

The role of large companies in semiconductor clusters should not be underestimated. Large firms act as miniature innovation systems in their own right, providing incubation space to employees, financing their own start-ups, offering technical expertise, product specifications and initial markets. In addition, large firms also provide a steady flow of trained people which small innovating firms can hire, and can share expertise with the supply chain[324].

Specifically in the semiconductor industry, most of the industry's key segments are dominated by a small number of large players. Large semiconductor companies have hundreds of suppliers. With production getting highly expensive, many small chip makers are becoming increasingly dependent on a few large foundries.

The importance of large companies for the semiconductor clusters can be observed in several examples. ASML is one of the world's leading providers of lithography systems for the semiconductor industry. The company has a dominant presence in the worldwide semiconductor industry and has had a large influence on the development of business activity in the Eindhoven region[325]. Many nanoelectronics companies in the region around Eindhoven were created/established around ASML. By rallying their suppliers around them, ASML makes sure that the region remains an attractive location for knowledge transfer and thus conducting the major part of their business[326]. Similarly, GLOBALFOUNDRIES and Infineon Technologies AG both had a strong influence on the development of Silicon Saxony[327] (Dresden, Germany), the same holds for STMicroelectronics in Grenoble (France).

A considerable influence of major semiconductor players can also be observed in other regions of the world. TSMC has proven to be pivotal for the development of the Taiwanese semiconductor industry. Fairchild, IBM and Intel are widely recognised for their influence on semiconductor clusters around the world. Moreover, their influence on the competitiveness of the industry in the region is still being recognised. For instance, Tech Valley (Albany, New York) owes its survival and growth to continuous large scale investments of IBM[328].

The importance of the presence of large companies in the semiconductor clusters was also confirmed by NESTA, the UK National Endowment for Science Technology and Arts. Specifically, the NESTA study demonstrated the consequences of having no large companies in the Silicon South

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[324] A Practical Guide to Cluster Development. A Report to the Department of Trade and Industry and the English RDAs by Ecotec Research & Consulting

[325] http://www.asml.com/asml/show.do?ctx=427

[326] http://nos.nl/artikel/276973-te-weinig-innovatie-in-industrie.html

[327] http://www.gtai.de/GTAI/Navigation/EN/invest,did=604968.html?view=renderPdf

[328] See http://www.poughkeepsiejournal.com/article/20090127/BUSINESS01/90127016/IBM-East-Fishkill-over-years?nclick_check=1 and http://www.globalfoundries.com/newsroom/2012/20120109.aspx

West cluster[329]. The study argued that the lack of large companies is a structural problem for the UK semiconductor industry. These companies could have played an important role in training and retaining knowledge workers and acquiring successful small businesses.

Additionally, the role of large companies for the industry is strengthened by the industry's capital-intensive nature. Setting up a chip fabrication factory requires billions of EUR of investments. As a result, it is only the biggest players who can keep up with state-of-the-art operations, as the cost of entry is extremely high.

An example can be found in the Global 450mm Consortium (G450C) abiding in Albany. The University at Albany partnered up with global industry leaders IBM, Intel, TSMC, GLOBALFOUNDRIES and Samsung to develop the next generation manufacturing technology. Moreover, leading tool makers such as ASML are also closely cooperating at the University at Albany and are expected to join. The G450C has already committed 4.4 billion USD to the region for the next 5 years, underlining the capital intensity needed for this research.

Two more examples can be found in the Grenoble cluster (Grenoble, France). For STMicroelectronics, the Crolles site has been a major centre of microelectronics research since the 1990s. The Crolles 2 Alliance brought together STMicroelectronics, Freescale and NXP from 2002 to 2007. It was one of the world's biggest research laboratories to work on future generations of CMOS technology, in particular etching (from 90 to 32 nanometre details) and fabrication methods on 300mm wafers. This collaboration agreement led to joint investments amounting to 2 billion EUR and a further 1.5 billion EUR in R&D expenditure. It was the largest single industrial investment in France in the last 15 years[330].

Consequently, large companies play a central role in the development of the European and global semiconductor industry. Specific measures helping to keep large semiconductor companies in Europe and comparisons with other regions of the world refer to tax incentives (see Section 4.3) and State Aid (see Section 4.5).

#### *4.4.1.2. The need to keep manufacturing in Europe*

Currently, a gap can be observed in Europe between manufacturing and R&D and design. Although European semiconductor clusters continue to be strong in R&D and circuit design, top-end manufacturing has diminished in Europe. ***Measures aimed at creating a better linkage between production facilities and the cluster ecosystem are therefore needed to effectively support manufacturing in the clusters.*** European policy needs to be aimed at measures that through regional networking aim to shift existing European fabs towards a higher level.

A question of keeping manufacturing in Europe instead of having fables clusters proves to be one of the central points of discussion. Keeping manufacturing in Europe is suggested to be crucial for a number of reasons. First, manufacturing is accountable for a significant number of jobs in Europe, especially for young people. Secondly, for the industry to be competitive, there is a clear need for an advanced system that integrates the whole value chain. The latter among others includes R&D,

[329] Shanmugalingam, S., Puttick, R., and Westlake, S. (2010). "Rebalancing Act", NESTA, available at: http://www.nesta.org.uk/library/documents/Rebalancing_Act.pdf
[330] http://www.minalogic.org/146-microelectronics-research-center-grenoble-france.htm

*Measures aimed at creating a better linkage between production facilities and the cluster ecosystem are therefore needed to effectively support manufacturing in the clusters. European policy needs to be aimed at measures that through regional networking aim to shift existing European fabs towards a higher level.*

design, manufacturing, services etc. Having a strong manufacturing base allows to increase the competitiveness of each other element of the value chain (creation and prototyping of new products, developing advanced equipment etc.). Furthermore, semiconductors industry being an enabling technology has spill-over effects on other industries like new energy, automotive, even textiles (based on nanotechnology) etc. For example, Japan is a world leader in automation solutions for transporting wafers within the manufacturing facilities. Consequently, a competitive semiconductor value chain has a much broader impact on innovation than just the semiconductor industry itself.

Therefore there is a need to ensure that Europe has an attractive industrial policy providing the framework to maintain and attract further manufacturing jobs in the region. However, the latest production and manufacturing technologies such as the 450mm - wafer fabs, require enormous amounts of capital expenses. Therefore, ***policy makers should support financing of and cooperation between companies that intend to invest into latest production technologies and manufacturing sites located in Europe***.

## 4.5. State Aid

One of the key policy areas that requires urgent attention of policy makers refers to State Aid measures in Europe. Three types of recommendations can be made here: (1) the rules for Regional State Aid need to be revised, specifically concerning the State Aid ceilings; (2) the matching clause needs to be extended to general State Aid law; and (3) the speed of State Aid procedures in Europe needs to be increased. Additionally, a critical viewpoint on State Aid funding should be that the greatest competition comes from outside Europe and not from within. Below we will first provide a brief overview of the State Aid measures in the analysed regions. We will then elaborate on each of the recommendations in more detail.

### 4.5.1. State Aid in the analysed regions

State Aid is reported to be crucial for the development of the semiconductor industry and is suggested to affect the key components of the innovation system such as networks and institutions[331]. State Aid has thus been an essential factor contributing to the establishment of the semiconductor clusters all over the world. The creation of favourable conditions allows to attract firms, human capital and investments into the cluster area. What makes State Aid particularly important for the semiconductor industry is the fact that the industry itself implies high R&D intensity and high (infrastructure-related) capital intensity which can be partially dealt with by means of State Aid. It is reported to be one of the key factors determining the decision of semiconductor companies to move to or stay in a certain region.

[331] Blümel C., Wydra S. (2012) “State Aid Regulation in the Nanoelectronics Innovation System”, EU-SPRI 2012 Karlsruhe

TABLE 4-4: Short overview of State Aid measures in different world regions

| World region | Overview |
|---|---|
| **STATE AID** | |
| **Short overview** | |
| **Europe** | Despite some complications related to State Aid use in Europe (which we will elaborate on in this chapter), all of the analysed European clusters report to have benefited from State Aid in one or another form. The provided aid is exclusively related to R&D support which corresponds to the general trend in Europe. Volumes, however, differ across the clusters. Moreover, In 2005, the reorientation of EU State Aid policy by the State Aid Action Plan was launched. This reorientation aimed to achieve "less and better targeted" State Aid. As a result, regional and sectoral aid were reduced and the maximum aid intensity (incentive as a percentage of the investment) for investment was adjusted downwards substantially. Nowadays, Regional Aid, for which Silicon Saxony is eligible, is limited to a State Aid intensity of ~10-11% for investments in excess of 50 million EUR. |
| **United States** | Recent State Aid investments in the semiconductor industry mostly relate to Tech Valley in this case. For Silicon Valley, Federal money played a crucial role when it was most needed, i.e., in 1940's – 1960's., but nowadays it does not anymore. In contrast, State of New York is very pro-active in securing semiconductor investments. Tech Valley provides a number of examples of large scale support for structural investments in education (specifically for nanoengineering), R&D and manufacturing. State Aid examples include an incentive package for GLOBALFOUNDRIES Fab 8 (1.4 billion USD, 33.33% Aid intensity for infrastructural investment), support for the G450C (~400M USD, ~10% Aid intensity for R&D investment), support for SEMATECH North (160M USD, 45.7% Aid intensity for R&D investment[332]). |
| **Asia** | State Aid support in the analysed Asian clusters mainly comprises funding, either through providing full start-up capital (Taiwan) or through State-Owned Enterprises (SOEs; China, Taiwan). Moreover, China offers extensive public support through the Five-Year-Plans for the industry. The current FYP ('11-'15) set the goal to move from a output based semiconductor industry (manufacturing) to a more R&D and design based semiconductor industry. In Taiwan, no taxes on fuel are levied to ensure the lowest energy prices, which is highly beneficial to the large share of manufacturing companies located there. |

When analysing State Aid measures relevant to the semiconductors industry, a distinction needs to be made between two types of State Aid: Regional Aid and R&D&I State Aid.The Regional Aid[333] framework in Europe refers to the aid for investment granted to large companies, or in certain limited circumstances, operating aid, which in both cases targets specific regions in order to reduce regional disparities[334]. Therefore only some regions are eligible for this type of State Aid. The maximum State Aid intensity (i.e., incentive as a percentage of the investment) varies among the eligible regions. It depends on the size of the regional GDP compared to the average EU GDP. Table 4-5 specifies the applicable ranges for maximum Regional Aid intensities. In our sample of analysed regions, only Dresden region qualifies for Regional Aid with a maximum of 30% aid intensity.

[332] The 160 million USD investment was directed at project support, see: http://www.siteselection.com/ssinsider/bbdeal/bd020722.htm

[333] Regional aid is aid awarded for an initial investment project. Initial investment means an investment in material and immaterial assets relating to: setting-up of a new establishment; extension of an existing establishment; diversification of the output of an establishment into new, additional products; a fundamental change in the overall production process of an existing establishment. 'Material assets' hear refer to the assets relating to land, buildings and plant/machinery. 'Immaterial assets' imply assets entailed by the transfer of technology through the acquisition of patent rights, licences, know-how or unpatented technical knowledge. Source: "Guidelines on national regional aid for 2007-2013", 2006/C 54/08

[334] "Guidelines on national regional aid for 2007-2013", 2006/C 54/08

TABLE 4-5: Overview of maximum Regional State Aid intensities[335]

| Regional GDP as % of EU-25 GDP | Maximum aid rates for large companies | Aid rates in the outermost regions[336] |
|---|---|---|
| > 75% | 10-15% | 40% |
| < 75% | 30% | 50% |
| < 60% | 40% | 60% |
| < 45% | 50% | n/a |

The R&D&I State Aid framework, in turn, refers to State Aid investments directly related to R&D&I activities. Different State Aid intensities are allowed for different types of activities. Table 4-6 provides an overview of the maximum State Aid intensities under the R&D&I framework.

TABLE 4-6: Overview of maximum R&D&I State Aid intensities[337]

| Type of R&D | Small enterprise | Medium-sized enterprise | Large enterprise |
|---|---|---|---|
| **Fundamental research** | 100% | 100% | 100% |
| **Industrial research** | 70% | 60% | 50% |
| **Industrial research subject to:**<br>• Collaboration between undertakings; for large undertakings; cross-border or with at least one SME; or<br>• Collaboration of an undertaking with a research organisation; or<br>• Dissemination of results. | 80% | 75% | 65% |
| **Experimental development** | 45% | 35% | 25% |
| **Experimental development subject to:**<br>• Collaboration between undertakings; for large undertakings; cross-border or with at least one SME; or<br>• Collaboration of an undertaking with a research organisation. | 60% | 50% | 40% |

In order to qualify for State Aid funding, a number of conditions need to be met[338]. ***None of the other analysed world regions were found to have detailed specifications of maximum State Aid intensities in place***.

**EU authorises aid of 457 million EUR for Crolles-3 R&D program[339]**

The European Commission has decided not to raise any objections under the State Aid rules to the financial support of 457 million EUR being granted by France for the Nano2012 R&D program. The support is part of a strategic investment program of 3.6 billion EUR being coordinated by STMicroelectronics that is expected to create 650 jobs. The program includes the CEA-LETI research center in Grenoble, France, and other industrial players and research bodies. IBM was mentioned in earlier descriptions of Nano2012, but was not included in the European Commission's statement on aid approval issued on 28 January 2009. The major portion of the aid, 340 million EUR went primarily to STMicroelectronics, the project leader. Nano2012 is expected to make use of the potential of the Crolles-Grenoble R&D ecosystem and help establish a cluster of derived technologies in Crolles.

Aid regulation aims to establish a level playing field on the internal market. Stakeholders, however, argue that there is little competition left in the semiconductor industry inside Europe. Instead,

335 EC (2008). "Vademecum: Community law on State Aid", Directorate-General for Competition.
336 An outermost region is a region that is part of a European Union Member State, but is situated outside of Europe. There are currently eight outermost regions, of which five are French, two are Portuguese and one is Spanish. For a full list, see http://ec.europa.eu/regional_policy/activity/outermost/index_en.cfm#6
337 Community framework for state aid for research and development and innovation, OJ C 323, 30.12.2006, p. 1–26.
338 For more information, please refer to the R&D&I framework legislation (2006/C 323/01)
339 http://www.eetimes.com/electronics-news/4194409/EU-authorizes-aid-of-600-million-for-Crolles-3-R-D-program

companies rather face competition from *outside* Europe[340]. Although this statement was not validated during the time of this study, we recommend the Commission to consider the merits of this statement. If it is indeed the case that little intra-EU competition remains, State Aid rules focused on establishing a level playing field on the internal market may conflict with the ability of semiconductor companies to compete at a global level.

**State of New York to grant GLOBALFOUNDRIES 1.4 billion EUR[341]**

The State of New York announced that GLOBALFOUNDRIES' 4.6 billion USD investment was successfully secured with the support of a 1.4 billion USD strong incentive package. It was reported that half of this was in direct funding and the remainder mostly in tax breaks. At the time of offering, the investment project was estimated at 4.2 billion USD, bringing the state aid intensity to 33.33%. In contrast to the example above, the support is also directly related to an infrastructural investment.

### *4.5.2. Revising the rules for Regional State Aid*

For Europe to be competitive in the ability to attract and retain global industrial players to the region, Regional Aid rules need to be adjusted. The State Aid ceilings that are in place require particular attention.

#### *4.5.2.1. Regional State Aid and State Aid ceilings*

In 2005, the reorientation of EU State Aid policy by the State Aid Action Plan was launched. The aim of the new approach was "less and better targeted" State Aid, i.e., reduced regional and sectoral aid, and significantly lowered maximum aid intensity for investments[342]. Effectively, ceilings were introduced that limit the State Aid intensity within the Regional Aid framework.

The ceilings for State Aid intensity refer to the maximum quota of the eligible costs of a project to which State Aid is allowed. Investments in excess of 50 million EUR are already greatly affected. For example, Silicon Saxony is allowed to offer a State Aid intensity of up to 30% under the current Regional Aid framework, but when it comes to large investments, this State Aid intensity gets significantly diluted by the current State Aid regulation.

In the box below, an example demonstrates how the effective State Aid intensity can be diluted for investment amounts greater than 50 million EUR.

[340] Stakeholders have suggested that only 5-10% of the European semiconductor industry can be characterised as intra-EU competition, whereas 90-95% is better described as competition from outside the EU.
[341] http://www.eetimes.com/electronics-news/4194409/EU-authorizes-aid-of-600-million-for-Crolles-3-R-D-program
[342] Adapted from Wydra S. (2011) "Innovation and industrial policy for Key Enabling Technologies in Europe – findings for micro/nanoelectronics and industrial biotechnology", paper presented at the 3rd European Conference on Corporate R&D and Innovation CONCORD-2011, October 6th 2011, Seville (Spain); available at http://iri.jrc.ec.europa.eu/concord-2011/papers/Wydra_Sven.pdf

**Example of reduction in State Aid intensity**

Consider a 1 billion EUR investment that creates 1000 WP. According to the incentive intensity rules, a maximum of 30% of the investment can be provided in State Aid. Hence:

30% x 1 billion EUR = 300 million EUR

However, as the funding for the project is vastly more than 50 million, the reductions need to be applied. The maximum amount of State Aid that can be provided can be described as following:

FQ = R*(50 + 0.5B + 0.34C)

Where FQ is the maximum funding quota, R* is the existing maximum incentive intensity, 50 (million) the amount that can be granted with the maximum incentive intensity, B the amount between 50-100 million EUR and C the amount above 100 million EUR.

The total amount of State Aid that can thus be provided on the 1 billion investment is:

0.3*(50+0.5*50+0.34*900) = 114.30 million EUR

The State Aid intensity thus equals 114.30 million EUR / 1 billion EUR = 11.43%

#### *4.5.2.2. A need for amending the State Aid ceilings under the Regional Aid Framework*

***Europe's position to compete with incentive packages around the world is currently weakened by its State Aid ceilings. Allowing for higher maximum aid intensities under the Regional Aid framework would help eligible regions to attract and retain leading-edge facilities in the region.***

Europe's position to compete with incentive packages around the world is currently weakened by the State Aid ceilings. While regions such as Silicon Saxony are allowed to provide a maximum State Aid intensity of 30% under the Regional Aid framework, this is reduced to ~10-11% for multi-billion euro investments. At the same time, Europe needs to compete with regions such as Tech Valley (US) offering up to 33% of the investment costs in State Aid incentives for infrastructural projects, and ~10% till up to 45.7% for R&D related projects.

If attracting and retaining leading-edge manufacturing facilities is of key importance for Europe, there is a clear need to consider the effect of State Aid regulation on the ability of regions to offer competitive incentive packages. Despite that, it needs to be emphasised that the value of the incentive package is only *one* of the factors influencing location-related decisions made by companies. Other factors, such as the quality of the available human capital or the availability of leading-edge research facilities, are also suggested to play a key role when companies make location-related decisions. Nevertheless, ***the current State Aid regulation sets limits on the ability of European regions to offer competitive incentive packages***, posing a risk that increasingly more companies will decide to move their facilities to and/or locate their new (leading-edge) facilities in other regions.

While it is a different discussion altogether as to whether European regions are *willing* to provide such incentive packages, it needs to be pointed out that under current State Aid regulation they simply *cannot*. ***Allowing for higher maximum aid intensities under the Regional Aid framework would help regions that can apply for Regional Aid to attract and retain leading-edge facilities in the region***. This, in turn, helps keep the European semiconductor clusters competitive. The decision on amending the State Aid ceilings can be connected to additional criteria in the balance test, which may for instance correspond to system failure[343].

### *4.5.3. Extending the matching clause to general State Aid law*

*The matching clause needs to be extended to general State Aid law. While it is also legally compatible with the Regional Aid framework, general State Aid law would be preferred as not all regions qualify for Regional Aid.*

In order to be able to offer competitive incentive packages, Europe needs to extent the matching clause for State Aid beyond the R&D&I framework. The results of the current study support the recommendation put forward by the High-Level Expert Group (HLG) on Key Enabling Technologies (KETs) in its June 2011 Final Report to introduce a general State Aid law matching clause[344].

While a matching clause already exists under current State Aid regulation, it is exclusive to the R&D&I framework. This exclusive focus prevents companies from filing cases under the matching clause for e.g. State Aid deals made in other countries that are specifically related to manufacturing. Moreover, by extending the matching clause to general State Aid law, or in any case the Regional Aid framework, the abovementioned effects of State Aid dilution could be avoided without the need to amend the State Aid ceilings.

#### *4.5.3.1. Legal compatibility of extending the matching clause*

The existing matching clause in the R&D&I-framework is reported to be compatible with both State Aid law and WTO law. Moreover, a further development of the matching clause can be held compatible with both[345]. One way to do so is to extend the matching clause's scope to include State Aid for manufacturing. Alternatively, a matching clause could be included in the Regional Aid framework. In contrast to the R&D&I-framework, such a matching clause would cover State Aid for production as long as it includes regional investment aid compatible with the Regional Aid framework. In any case, either option would not require fundamental changes to the State Aid legal system[346].

Introducing a matching clause to the Regional Aid framework, however, has certain limitations. Regions in Europe that cannot apply for Regional State Aid also cannot apply for the additional matching clause. While this would, for example, solve the issue for the state of Saxony for now, it has no effect on, for example, the Grenoble area in France. Therefore general State Aid law is preferred.

[343] Wydra S. (2011) "Innovation and industrial policy for Key Enabling Technologies in Europe – findings for micro/nanoelectronics and industrial biotechnology", paper presented at the 3rd European Conference on Corporate R&D and Innovation CONCORD-2011, October 6th 2011, Seville (Spain); available at http://iri.jrc.ec.europa.eu/concord-2011/papers/Wydra_Sven.pdf

[344] European Commission (2011). "High-Level Expert Group on Key Enabling Technologies: Final Report", Brussels.

[345] Redeker Sellner Dahs (2012). "Short Legal Opinion on the Conformity and Practability of State Aid Law Matching Clauses", commissioned by the Saxon State Ministry of Economic Affairs, Labour and Transport.

[346] Redeker Sellner Dahs (2012). "Short Legal Opinion on the Conformity and Practability of State Aid Law Matching Clauses", commissioned by the Saxon State Ministry of Economic Affairs, Labour and Transport.

#### 4.5.3.2. *Confidentiality of State Aid deals outside Europe*

The existing matching clause from the R&D&I-framework has not been used by the semiconductor industry to date. Apart from the exclusive focus on R&D&I, it is suggested that this is also related to the fact that incentive packages are almost exclusively made in full confidentiality. This prevents industry from formally asking for the application of a matching clause.

If the matching clause is extended to the general State Aid law, a mechanism would need to be put in place that allows companies to disclose the relevant information. Alternatively, the Commission could access the EU Market Access teams for further information, as well as consider sending out information requests. These sources could then be used to form plausible ranges of State Aid proposals outside the EU, which may ultimately be used for the judgement of the situation. The Commission could also base its decisions on circumstantial evidence, as is already the case with the existing matching clause[347].

### 4.5.4. *Increasing the speed of procedures*

There is a clear need for a reduction in bureaucracy and an increased speed of procedures in the European State Aid application process. A fast decision-making process is necessary for Europe to raise its attractiveness for large-scale investments.

Table 4-7 provides a general overview of the different decision making processes in the regions.

TABLE 4-7: General comparison of State Aid decision making processes across the regions[348]

| World region | Type of process | Perception of decision process | Outcome | Rank |
|---|---|---|---|---|
| **STATE AID** | | | | |
| **Comparison of the decision making process among the regions** | | | | |
| **Europe** | • Involvement of multiple actors at regional, Member State and European levels<br>• Lengthy process with repeated information requests | • Long and bureaucratic[349] | • Uncertainty on whether State Aid is granted;<br>• State Aid intensity may be significantly reduced for large-scale investments. | **3** |
| **United States** | • Involvement of State level officials, both from public institutions (e.g. Economic Development Corporation) and public administration<br>• Lengthy and noisy, i.e., high level of involvement | • Long, bureaucratic and "noisy"[350] | • A solid outcome is generally expected (also evidenced by the recent State Aid volumes in Tech Valley). | **2** |

[347] Redeker Sellner Dahs (2012). "Short Legal Opinion on the Conformity and Practability of State Aid Law Matching Clauses", commissioned by the Saxon State Ministry of Economic Affairs, Labour and Transport.
[348] Based on stakeholder interviews; European Commission (2012), "The role of Taxation, IPR and State Aid in EU ICT competitiveness: Report of a High-Level Panel Discussion", DG Connect, Brussels.
[349] There are various examples of cases for which a decision took well over a year, such as some experiences in Silicon Saxony concerning GLOBALFOUNDRIES and Qimonda.
[350] As not recent State Aid was identified for Silicon Saxony, this specifically applies to Tech Valley. It is based on recent experiences concerning the GLOBALFOUNDRIES fab in Malta and State Aid investments at UAlbany.

| World region | Type of process | Perception of decision process | Outcome | Rank |
|---|---|---|---|---|
| | from the press. | | | |
| **Asia** | • One-stop-service<br>• Quiet and considered to be efficient | • Short (typically 2-6 months), efficient and quiet. | • By openly recognising the strategic importance of the sector, stakeholders expect efficient and solid outcomes. | **1** |

***The speed of State Aid procedures in Europe needs to be increased by streamlining the process. The aim should be to reduce the decision time to 2-3 months, which may be achieved through preventing unnecessary information requests and through involvement of all actors from the start of the procedure.***

In comparison to regions outside the EU, particularly East Asian countries, Europe is regarded as having a long and bureaucratic process in place. The European State Aid process involves multiple actors at regional, Member State and European levels, and involves complicated procedures. The final report of the HLG on KETs specifically addresses that the procedures relating to State Aid notifications bring about a high administrative burden[351]. Moreover, it was argued that particularly for high levels of investment, the administrative burden is increased[352].

In the United States, State Aid is granted at state level, reducing some of the bureaucracy. Experts, however, have also claimed that the process in the US is particularly lengthy and attracts significant attention in the press[353]. Despite the long and "noisy" process, they also argued that it often results in solid deals.

Conversely, Asian countries are reported to offer a fast and efficient process, mainly owing to the one-stop-shop approach[354]. The duration of the process varies on a case-by-case basis. For specific cases that are of strategic importance to the region, stakeholders noted that fast decision processes of a couple of months are possible.

Singapore was often regarded by stakeholders as the current benchmark of an effective State Aid process. Although the Singapore cluster was not included in this study, this has been confirmed by both the Singapore Economic Development Board (EDB) and industry, as well as in previously conducted studies[355]. The EDB offers a one-stop-service and works on a case-by-case basis. Depending on the strategic importance of the company for the region, State Aid deals are typically finalised in 2-6 months[356].

[351] European Commission (2011). "High-Level Expert Group on Key Enabling Technologies: Final Report", Brussels.
[352] Drews, J. (2012). "Public consultation on the revision of the European Union rules on regional State aid", European Commission, Brussels, available at http://ec.europa.eu/competition/consultations/2012_regional_stateaid/germany_globalfoundries_en.pdf
[353] European Commission (2012), "The role of Taxation, IPR and State Aid in EU ICT competitiveness: Report of a High-Level Panel Discussion", DG Connect, Brussels.
[354] European Commission (2012), "The role of Taxation, IPR and State Aid in EU ICT competitiveness: Report of a High-Level Panel Discussion", DG Connect, Brussels.
[355] European Commission (2011). "High-Level Expert Group on Key Enabling Technologies: Final Report", Brussels.
[356] Indicated by stakeholders from various groups. Note that only in extreme cases, deals were made in 2 months.

In Europe, time for deciding on cases needs to be limited by simplifying and streamlining the procedures of particularly the notification process. Decision time should be cut to 2-3 months. To achieve this goal, the HLG on KETs has suggested to cut time by preventing unnecessary information requests. This, in turn, can be achieved by improving the mutual understanding of all involved parties. One possibility is to involve all required actors from the beginning of the notification procedure. Directly involving them prevents having to explain the details on many occasions and may significantly streamline the process. Moreover, by ensuring that businesses understand what type of information is needed by the Commission, data can be handed over as efficiently as possible[357].

[357] European Commission (2011). "High-Level Expert Group on Key Enabling Technologies: Final Report", Brussels.

# *Annex A: Operationalised research questions at a cluster level*

TABLE A-1: Operationalisation of research questions and identification of stakeholders, sources, tools and techniques

| General research questions (1) | Key questions cluster level (2) | *Examples* of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| **Dimension 1: Policy measures and incentives** | | | | |
| ***1.1 What are the motives for the State Aid in semiconductors? How important is the State Aid relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What types of State Aid are available to the members of the cluster (including a brief description)? E.g.:<br>o Grants to firms for investment, R&D, employee training, etc.;<br>o Loans and guarantees below market rates;<br>o Free or subsidised consultancy advice;<br>o Cash injections to and writing off losses of public enterprises;<br>o Sale or lease of public land or property at discounted rates;<br>o Contracts not open to competitive tendering;<br>o Discretionary deferral of or exemption from tax, social security and other payments to the state;<br>o Legislation to protect or guarantee market share;<br>o Funding/cash injections to non-profit social enterprises, community companies and some charities;<br>o Public funding of privately owned infrastructure.<br>(2) What are the key motives of the government to provide State Aid (state subsidies)?<br>(3) Whether the cluster has used State Aid, and if so, what type was used, and what was the impact for the cluster?<br>(4) How important is State Aid relative to other influential factors with regard to international competitiveness?<br>(5) Barriers and challenges (e.g., coordination problems, the nature of innovation as a public good) | Consultation on the Review of the EU state aid rules for research, development and innovation (R&D&I) at http://ec.europa.eu/competition/consultations/2012_stateaid_rdi/index_en.html<br>State Aid regulations of the respective countries (legislative acts)<br>Relevant communications from the Commission<br>Overview of national measures adopted as a response to the financial/economic crisis at http://europa.eu/ | Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| ***1.2 What are the motives for the R&D*** | (1) What examples of tax advantages are relevant to the | PwC publication "Effective Tax Rate | Industry | Desk-research (see |

| General research questions (1) | Key questions cluster level (2) | *Examples* of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***tax incentives in semiconductors? How important are tax incentives relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | cluster (including a brief description)? e.g.:<br>o R&D tax credits;<br>o 'tax holidays';<br>o Indirect tax incentives (GST, VAT, CST etc.).<br>(2) What are the key motives of the government to provide such incentives?<br>E.g.:<br>o Creating a real incentive for public-private partnerships to fuel innovation and economic activity;<br>o Spurring innovation and start-up companies;<br>o Seeding surrounding areas with additional investment in not only scientific research but also indirect business benefits;<br>o Anchoring high-tech business investments near research facilities;<br>o Enabling rapid time-to-market production when manufacturing plants are located close to research; etc.<br>(3) How do those tax incentives help to expand the cluster and keep it competitive?<br>(4) How important are tax incentives relative to other influential factors with regard to international competitiveness?<br>(5) Barriers and challenges | Analysis: Semiconductor Industry"<br>PwC analysis "Compensation Practices of Fabless Semiconductor Companies"<br>PwC analysis "Public Company Segment Disclosures"<br>PwC analysis "Benchmarking Semiconductor Critical Accounting Policies"<br>SIA Tax for semiconductors in the United States overview at http://www.sia-online.org/public-policy/tax/<br>KPMG 2010 "Asia Pacific Indirect tax country guide"<br>ESIA 2008 Competitiveness report | representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | column 3)<br>Interviews |
| ***1.3 What are the motives for the favourable trade conditions in semiconductors? How important are*** | (1) With which countries does the cluster have favourable trade conditions?<br>(e.g., agreements between two or more countries to establish a free trade area where commerce in goods and services can be conducted across their common borders, | European Commission Trade at http://ec.europa.eu/trade/<br>United States Trade agreements at http://www.ustr.gov/trade-agreements | Industry representatives<br>Representatives of cluster organisations (if applicable) | Desk-research (see column 3)<br>Interviews |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***favourable trade conditions relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | without tariffs or hindrances but (in contrast to a common market) capital or labour may not move freely)<br>(2) What are the key motives of the government to have favourable trade conditions (economic integration vs. customs union)?<br>E.g.:<br>o Non-discrimination for foreign products in all markets;<br>o An end to investment restrictions tied to technology transfer requirements;<br>o Zero duties on multi-chip packages;<br>o Reduction of tariff and non-tariff barriers;<br>o Removal of impediments to e-commerce;<br>o Elimination of copyright levies on digital products;<br>o Passage of the pending Free Trade Agreements; etc.<br>(3) How do favourable trade conditions help to expand the cluster and keep it competitive?<br>(4) How important are favourable trade conditions relative to other influential factors with regard to international competitiveness?<br>(5) Barriers and challenges | PwC publication 2009 "China's free trade agreements: Lowering landing costs and gaining competitive advantage"<br>SIA "Export controls for semiconductors in the United States" overview at http://www.sia-online.org/public-policy/export-controls/ | Policy makers | |
| ***1.4 What are the motives for the pre-commercial public procurement for*** | (1) Examples of pre-commercial public procurement present in the cluster, e.g.:<br>o Early stage innovation of emerging technologies358; | Pre-commercial public procurement regulations of the respective countries | Industry representatives<br>Representatives of | Desk-research (see column 3)<br>Interviews |

[358] the development of commercially usable prototypes and pilot projects for the purpose of conducting technological and/or marketing experiments, where the prototype is necessarily the final commercial product and where it is too expensive to produce for it to be used only for demonstration and validation purposes; technical evaluations and feasibility studies preparatory to the launch of a new product, which will include the costs for software and computer modeling for the purpose of conducting technological and/or marketing experiments; testing and laboratory costs; expenses for adapting technologies to particular production specifications and for optimising the production process, up to the production of the first pre-series batch

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***semiconductors? How important is pre-commercial public procurement relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | ○ Adaptations or improvements of existing solutions (incremental innovation);<br>○ Non-technological innovation characterised by<br>○ organisational and management changes etc.).<br>(2) What are the key motives of the government in offering pre-commercial public procurement?<br>(3) How does pre-commercial public procurement help to expand the cluster and keep it competitive?<br>(4) How important is pre-commercial public procurement relative to other influential factors with regard to international competitiveness?<br>(5) Barriers and challenges | COM(2007) 799 Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe<br>"US defence R&D spending: an analysis of the impacts", EURAB report, PREST, 2004, quoted in COM(2007) 799<br>"Pre-commercial procurement of innovation: A missing link in the European innovation cycle", National IST Research Directors Forum Working Group on Public Procurement in support of ICT Research and Innovation, March 2006 at ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/pcp/precommercial-procurement-of-innovation_en.pdf | cluster organisations (if applicable)<br>Policy makers | |
| ***1.5 How important is access to finance (seed capital, venture capital, loans) relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable*** | (1) What is the level of availability of different types of finance in the cluster (e.g., seed capital, venture capital, loans)? What is the role of government in stimulating the presence of different types of private funds in the cluster?<br>○ Availability of pre-seed capital<br>○ Availability of seed-capital<br>○ Availability of venture capital<br>○ Availability of governmental funds<br>○ Availability of EU structural funds (if applicable)<br>(2) How does access to finance help to expand the cluster and keep it competitive?<br>(3) How important is access to finance relative to other influential factors with regard to international | PwC publication "Venture Capital Trends in the Semiconductor Industry"<br>PwC publication "Semiconductor Financial Benchmarking Analysis – Public Equipment Companies"<br>PwC analysis "Semiconductor Financial Benchmarking Analysis - Fabless Companies"<br>PwC analysis "Semiconductor Financial Benchmarking Analysis – Public Device Manufacturers" | Industry representatives<br>Venture capital investors<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***to the European context?*** | competitiveness?<br>(4) Barriers and challenges | | | |
| ***1.6 What are the motives for forming public-private partnerships for semiconductors? How important are public-private partnerships relative to other influential factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What examples of public-private partnerships are present in the cluster?<br>(2) How do public-private partnerships help to expand the cluster and keep it competitive? E.g.:<br>o Important means for the delivery of long-term infrastructure assets and related services;<br>o Important means of maintaining economic activity during the crisis.<br>(3) How important are public-private partnerships relative to other influential factors with regard to international competitiveness?<br>(4) Barriers and challenges | First interim evaluation of the ARTEMIS and ENIAC Joint Technology Initiatives, European Commission, 2010<br>ENIAC Annual activity reports and work programmes at http://www.eniac.eu/web/documents/general.php | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| ***1.7 How important are other policy measures and incentives relative to the abovementioned factors with regard to international competitiveness? What best practices can be found outside Europe (Asia, US), and to what extent*** | (1) What other policy measures influence the development of the cluster? E.g.:<br>o Harmonisation of ICT standards and standardisation processes,<br>o Single market regulation;<br>o Market surveillance on unsafe products;<br>o IP Regulation;<br>o Bonuses for cross border cooperation and dissemination;<br>o Enhancing semiconductor workforce;<br>o Eliminating new tariffs on emerging semiconductor devices; | ICT Standardisation in the European Union at http://ec.europa.eu/enterprise/sectors/ict/standards/<br>Overview of public policies for semiconductors in US at http://www.sia-online.org/public-policy/public-policy/<br>Sectoral Innovation Foresight Electrical and optical equipment Interim Report, ELECTRA 2008 | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***are those applicable - to the European context?*** | ○ Advancing environmental initiatives and trade liberalisation;<br>○ Upholding strong anti-dumping laws and effective anti-dumping remedies; etc.<br>2) How do these measures help to expand the cluster and keep it competitive?<br>(3) How important are these measures relative to other influential factors with regard to international competitiveness?<br>(4) Barriers and challenges | ESIA 2008 Competitiveness Report | | |
| **Dimension 2: R&D&I capacities** | | | | |
| ***2.1 What are the current R&D&I capacities in EU Member States and regions in the field of semiconductors?*** | (1) What are the current R&D&I capacities of the cluster in the field of semiconductors?<br>E.g.:<br>○ The presence of regional integrated expert centres, technology-transfer centres and innovation centres forming regional intellectual and R&D&I bases;<br>○ The availability of innovation services, SME consultancy, education and training;<br>○ The presence of large companies;<br>○ The presence of strong innovative SME base. | Semiconductor research laboratories within the European Union at http://www.semiconductors.co.uk/research_laboratories/europe-eu_k-to-z.htm<br>ESIA 2008 Competitiveness Report<br>2010 EU Industrial R&D Investment Scoreboard<br>"Vision, mission and strategy: R&D in European Micro- and Nanoelectronics", AENEAS report at http://www.aeneas-office.eu/web/downloads/aeneas/vms_final_feb2011_1.pdf | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| ***2.2 What adjustments in framework*** | (1) What adjustments in the framework conditions would allow for boosting the current R&D&I capacities of the cluster? | First interim evaluation of the ARTEMIS and ENIAC Joint Technology Initiatives, European | Representatives of universities and research institutes | Desk-research (see column 3) |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***conditions would allow for boosting the current R&D&I capacities in Europe? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | E.g.:<br>○ Launching programmes and curricula at all levels able to raise innovation awareness dramatically and to attract both new students and teachers to all disciplines in the nano-/microelectronic sciences;<br>○ Encouraging the creation and expansion of new firms in high-technology sectors, calling on financial markets and venture capital investment capabilities;<br>○ Applying a generalised / harmonised tax credit scheme for R&D; if necessary by establishing topical specifications related to micro/nanoelectronics in order to apply it on a case by case basis. | Commission, 2010<br>Federal research initiatives for semiconductors in the United States at http://www.sia-online.org/public-policy/research-technology/<br>ESIA 2008 Competitiveness Report<br>Chips with everything. Lessons for effective government support for clusters from the South West semiconductor industry, http://www.nesta.org.uk/library/documents/Semiconductorsv10.pdf | Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Interviews |
| ***2.3 What unique demands are put on European companies maintaining R&D investments at high levels in a highly globalised economic environment? How can policy measures and incentives help companies meet these demands?*** | (1) What unique demands are put on the companies from the cluster which maintain R&D investments at high levels in a highly globalised economic environment?<br>E.g.<br>○ Decentralisation of R&D units;<br>○ Customer-centric orientation;<br>○ The pressure to improve productivity, lower the costs and save time;<br>○ The need to retain expertise in the core competencies;<br>○ Synchronisation of global resources;<br>○ Development of internal innovation management system; etc.<br>(2) How can policy measures and incentives help companies meet these demands? | PwC publication 2009 "A change of pace in semiconductor industry"<br>IHS iSuppli Market research results at http://www.isuppli.com/semiconductor-value-chain/pages/headlines.aspx | Industry representatives | Desk-research (see column 3)<br>Interviews |
| **Dimension 3: Effect of innovation policy and industrial policy regimes** | | | | |
| ***3.1 What innovation*** | (1) What innovation policy and industrial policy measures are | ESIA 2008 Competitiveness Report | Representatives of | Desk-research (see |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***policy and industrial policy measures are needed to effectively support R&D&I efforts in semiconductors? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | needed to effectively support R&D&I efforts in the cluster?<br>E.g.:<br>o Promoting and leading international cooperation;<br>o Encouraging the creation and expansion of new firms in high-technology sectors, calling on financial markets and venture capital investment capabilities;<br>o Leveraging the 'institutional' capabilities academia (universities and research institutes) and regional and local government bodies provide to extend and exploit their research infrastructures such as science parks, incubators, venture partnering, etc;<br>o Creating incentives for clusters; etc.<br>(2) Which of those measures are already present in the cluster? | 2010 EU Industrial R&D Investment Scoreboard<br>"Vision, mission and strategy: R&D in European Micro- and Nanoelectronics", AENEAS report at http://www.aeneas-office.eu/web/downloads/aeneas/vms_final_feb2011_1.pdf | universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | column 3)<br>Interviews |
| ***3.2 What innovation policy and industrial policy measures are needed to effectively support semiconductor manufacturing? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What innovation policy and industrial policy measures are needed to effectively support semiconductor manufacturing in the cluster?<br>E.g.:<br>o Encouraging end-use industry base;<br>o Reaching standard agreements quickly and effectively;<br>o Launching cross-industry cross-border initiatives; etc.<br>(2) Which of those measures are already present in the cluster? | "Incentives to Encourage Electronics Manufacturing in Europe", VDI/VDE-IT 2011 at http://cordis.europa.eu/fp7/ict/micro-nanosystems/docs/ictman/ict-man-objective-5_en.pdf<br>SMART 2011/0063 ("Strategies for innovative and effective ICT Components & Systems Manufacturing in Europe") | Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |

| *General research questions (1)* | *Key questions cluster level (2)* | *Examples of relevant secondary data sources (3)* | *Key stakeholders (4)* | *Relevant tools and techniques (5)* |
|---|---|---|---|---|
| ***3.3 What innovation policy and industrial policy measures are needed to effectively support the creation of new market opportunities for semiconductors? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What innovation policy and industrial policy measures are needed to effectively support the creation of new market opportunities for semiconductors?<br>E.g.:<br>o Focusing industry-wide innovation incentives on semiconductor systems know-how for new applications.<br>(2) Which of those measures are already present in the cluster? | ESIA 2008 Competitiveness Report<br>Digital Agenda for Europe, http://ec.europa.eu/information_society/digital-agenda/documents/digital-agenda-communication-en.pdf | Industry representatives | Desk-research (see column 3)<br>Interviews |
| ***3.4 What innovation policy and industrial policy measures are needed to effectively attract a highly skilled workforce and encourage more students to complete technological studies? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What innovation policy and industrial policy measures are needed to effectively attract a highly skilled workforce and encourage more students to complete technological studies?<br>E.g.:<br>o Making micro- and nanoelectronics a priority educational objective and development theme, ranging from awareness in the primary-to-high school education followed by developing multi-disciplinary curricula in academic training;<br>o Launching programmes and curricula at all levels able to raise innovation awareness dramatically and to attract both new students and teachers to all disciplines in the nano-/microelectronic sciences.<br>(2) Which of those measures are already present in the cluster? | Semiconductor workforce policy in the United States at http://www.sia-online.org/public-policy/workforce/<br>ESIA press release "Industrial innovation policy is needed to keep Europe in the lead in the global technology race", http://www.catrene.org/web/medeaplus/releases.php<br>Strategic framework for European cooperation in education and training ("ET 2020")<br>Overviews of nanotechnology Workforce Programs, http://www.scribd.com/doc/50302695/cap-10-nano-workforce- | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |

| *General research questions (1)* | *Key questions cluster level (2)* | *Examples of relevant secondary data sources (3)* | *Key stakeholders (4)* | *Relevant tools and techniques (5)* |
|---|---|---|---|---|
| | | program<br>Nanoelectronics Workforce Development Initiative | | |
| ***3.5 What are the differentiated effects of the innovation policy and industrial policy regimes on different types of semiconductor firms?*** | (1) How do the abovementioned policy measures influence different types of firms in the cluster?<br>o Size (Large vs. SMEs)<br>o Value chain (Integrated device manufacturers (IDM), fables, licensing, foundry and back-end processes (assembly and test, packaging) etc.) | ESIA 2008 Competitiveness Report<br>A Research on the Innovation Promoting Policy for SMEs in APEC: Survey and Case Studies.<br>APEC SME Innovation Center, http://www.apec-smeic.org/_file/pdf/Innovation_Promoting_Policy_SMEs_APEC_Eng_02summary.pdf | Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| **Dimension 4: Technology transfer from research organisations and universities to companies** | | | | |
| ***4.1 What policies and measures are needed to effectively support technology transfer from universities to industry at the individual level (scientists)? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What policies and measures are needed to effectively support technology transfer from universities to industry at the individual level (scientists)?<br>E.g.:<br>o Funds for labour-mobility work;<br>o Allowing part-time positions;<br>o Public funds for collaborative research;<br>o Revenue sharing rules;<br>o Funds for entrepreneurship;<br>o University patent legislation; etc.<br>(2) Which of those measures are already present in the cluster? | Monitoring and analysis of technology transfer and intellectual property regimes and their use", 2009 Expert Group on Knowledge Transfer Report, DG Research<br>COM(2009) 158 final "A new partnership for the modernisation of universities: the EU Forum for University Business Dialogue", European Commission | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| ***4.2 What policies and measures are needed to effectively support*** | (1) What policies and measures are needed to effectively support technology transfer from universities to industry at the institutional level (universities)? | Monitoring and analysis of technology transfer and intellectual property regimes and their use", | Representatives of universities and research institutes | Desk-research (see column 3) |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***technology transfer from universities to industry at the institutional level (universities)? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | E.g.:<br>o Benchmarking exercises;<br>o Funding policies;<br>o University patent legislation; etc.<br>(2) Which of those measures are already present in the cluster? | 2009 Expert Group on Knowledge Transfer Report, DG Research<br>COM(2009) 158 final "A new partnership for the modernisation of universities: the EU Forum for University Business Dialogue", European Commission | Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Interviews |
| **Dimension 5: Technology transfer between the nanoelectronics manufacturing companies and the different application customers** | | | | |
| ***5.1 To what extent do the current clustering models of semiconductor clusters incorporate end-user industries?*** | (1) What are the key benefits for semiconductor clusters in incorporating end-user industries?<br>E.g.:<br>o Ensuring competitive differentiation;<br>o Capturing new market opportunities through standardisation; etc.<br>(2) What form does such incorporation take?<br>E.g.:<br>o Direct business alliances or partnerships between semiconductor companies and application companies;<br>o Centres of excellence based on common interests and complementary capabilities; etc.<br>(3) What is the role of semiconductor companies in cooperation with end-user industries?<br>E.g.: | ESIA Semiconductor Europe newsletter, October 2010<br>2008 ESIA Competitiveness Report | Industry representatives<br>Representatives of cluster organisations (if applicable) | Desk-research (see column 3)<br>Interviews |

| *General research questions (1)* | *Key questions cluster level (2)* | *Examples of relevant secondary data sources (3)* | *Key stakeholders (4)* | *Relevant tools and techniques (5)* |
|---|---|---|---|---|
| | ○ Full R&D development & engineering for applications and new solutions; etc.<br>(4) What are the key barriers for incorporating end-user industries into the semiconductor clusters? | | | |
| ***5.2 What policy measures can help semiconductor companies get access to, and be in proximity of, end-user industries? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What policy measures can help semiconductor companies get access to, and be in proximity of, end-user industries?<br>(2) Which of those measures are already present in the cluster? | ESIA Semiconductor Europe newsletter, October 2010<br>2008 ESIA Competitiveness Report | Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| **Dimension 6: Different clustering models for different types of activities worldwide** | | | | |
| ***6.1 What clustering models of semiconductor clusters can be identified?*** | (1) What is the clustering model of the current cluster?<br>Criteria:<br>○ Initiation (top-down vs. bottom-up)<br>○ Funding<br>○ Research<br>○ Coordination<br>○ Specialisation<br>○ Network structure<br>Grassroots/network/hybrid/… | Cluster Management Excellence Volume II: Sustainability and Effectiveness of Clusters and Networks<br>"Boosting innovation: the cluster approach" (1999), OECD proceedings<br>2008 ESIA Competitiveness Report | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| ***6.2 What is the role*** | (1) What is the role of cluster organisations in semiconductor | Meier zu Köcker, G.; Buhl, C. (2009) | Representatives of | Desk-research (see |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***of cluster organisations in semiconductor clusters? What are the specific characteristics of cluster organisations in these clusters (e.g., size, organisational structure, type of provided services, strategy and focus, funding etc.)? What are the key differences in the way clusters are organised within and outside the EU?*** | clusters?<br>E.g.:<br>o Match-maker between academia and industry;<br>o Facilitator of networking events;<br>o General information point on the cluster (including a directory of participating companies and other organisations); etc.<br>(2) What are the specific characteristics of cluster organisations in these clusters?<br>• Size:<br>  o a secretariat of 1-3 FTEs;<br>  o medium-level cluster organisation (3-8 FTEs)<br>  o large cluster organisation (9 and more FTEs)<br>• Organisational structure:<br>  o Project, not an individual organisation (with appointed project team);<br>  o Individual organisation (foundation, association, public-private partnership etc.)<br>  o Other<br>• Type of provided services<br>  o Networking (institutional networks, seminars, workshops, conferences on scientific and business issues, social events, newsletters);<br>  o Providing information/signposting (websites, company directories, port of call for inward investors, company visits);<br>  o Articulating needs/lobbying (interaction with local government, interaction with national government);<br>  o Collaboration/joint action (purchasing | "Cluster Management Excellence, Volume I: Network Services"<br>"Cluster Management Excellence, Volume II: Sustainability and Effectiveness of Clusters and Networks" (2009), Federal Ministry of Economics and Technology Public Relations Department<br>"Uncovering excellence in cluster management" (2011), PwC Thought Leadership report<br>European Cluster Excellence BASELINE : Minimum Requirements for Cluster Organisations at http://www.cluster-excellence.eu/fileadmin/_cluster-excellence/grafiken/20111128_European_Cluster_Excellence_BASELINE_web.pdf | universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations<br>Policy makers | column 3)<br>Interviews |

| *General research questions (1)* | *Key questions cluster level (2)* | *Examples of relevant secondary data sources (3)* | *Key stakeholders (4)* | *Relevant tools and techniques (5)* |
|---|---|---|---|---|
| | consortia, equipment sharing schemes, mutual access to libraries, access to legal expertise/documentation);<br>o Education/training (seminars/workshops on specific topics, e.g. regulatory issues, marketing, business development; encourage training institutions to put on courses);<br>o Cluster promotion (attending trade fairs/conferences, organising conferences, partnering events with overseas companies, presentations for local companies);<br>o Access to technological platforms/ scientific equipment;<br>o Other<br>• Strategy and focus (e.g., exclusive focus on semiconductor industry vs. multi-sectoral orientation)<br>• Funding and membership model<br>o Public only<br>o Private only<br>o Combination of public and private<br><br>(3) What are the key differences in the way clusters are organised within and outside the EU? | | | |
| ***6.3 What are the key differences between clustering models of semiconductor clusters in Europe and outside Europe (Asia, US)?*** | Question relevant for cross-case analysis | Cluster Management Excellence Volume II: Sustainability and Effectiveness of Clusters and Networks<br><br>"Boosting innovation: the cluster approach" (1999), OECD proceedings | Outputs of cluster-level case study analysis | Cross-case analysis techniques |

| General research questions (1) | Key questions cluster level (2) | *Examples* of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| | | 2008 ESIA Competitiveness Report | | |
| ***6.4 What policy measures are effective in supporting the identified clustering models? What best practices can be found outside Europe (Asia, US), and to what extent are those applicable to the European context?*** | (1) What policy measures are effective in supporting this particular type of clustering model? (possible roles of the government: facilitation, support, intervention, steering) | High Tech Specialization: A Comparison of High Technology Centers at http://www.brookings.edu/~/media/Files/rc/reports/2001/ | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| **Dimension 7: Potential for new clusters or further networking** | | | | |
| ***7.1 Where in Europe do new semiconductor clusters currently emerge or are likely to emerge? What are the key emerging semiconductor clusters outside Europe?*** | (1) What emerging semiconductor clusters in Europe can be identified by the cluster members (stakeholders from the sample)?<br>(2) What emerging semiconductor clusters outside Europe can be identified by the cluster members (stakeholders from the sample)? | PwC publication "See the future: Top industry clusters 2040 revealed"<br>Vision, Mission and Strategy. R&D in European Micro-and Nanoelectronics. http://www.aeneas-office.eu/web/downloads/aeneas/vms_final_feb2011_1.pdf | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of cluster organisations (if applicable)<br>Policy makers | Desk-research (see column 3)<br>Interviews |
| ***7.2 What is the potential of further networking among European and between European and non-European semiconductor*** | (1) What is the potential for further networking between the cluster in question and other semiconductor clusters within and outside Europe?<br>(2) For which stages of the value chain/types of semiconductor companies of the cluster in question is global networking particularly crucial? | Sternberg R. (2003) New Firms, Regional Development and the Cluster Approach – What Can Technology Policies Achieve? Broecker J., Dohse D., Soltwedel R. (eds.) Innovation Clusters and Interregional Competition. Berlin | Representatives of universities and research institutes<br>Industry representatives<br>Representatives of | Desk-research (see column 3)<br>Interviews |

| General research questions (1) | Key questions cluster level (2) | Examples of relevant secondary data sources (3) | Key stakeholders (4) | Relevant tools and techniques (5) |
|---|---|---|---|---|
| ***clusters? For which stages of the value chain/types of semiconductor companies is global networking particularly crucial? What policy measures can effectively stimulate such networking?*** | (3) What policy measures can effectively stimulate such networking?<br><br>(4) Which of those policy measures are already present in the cluster? | Heidelberg, Springer-Verlag<br><br>The Exploration of Technological Diversity and Geographic Localization in Innovation: Start-Up Firms in the Semiconductor Industry. Paul Almeida and Bruce Kogut, Small Business Economics Volume 9, Number 1, 21-31, DOI: 10.1023/A:1007995512597 | cluster organisations (if applicable)<br><br>Policy makers | |

# Annex B: Public consultation questionnaire

***Introduction***

Welcome to the online public consultation on policy measures needed to create, expand and keep semiconductor clusters in Europe competitive.

This public consultation aims to collect inputs for evidence-based policy recommendations that would allow national and European policy makers to develop effective measures in order to improve the "European advantage" of the semiconductors industry. The recommendations will also aim to link national/regional level clusters and the most effective measures to the future European level programmes, like Horizon 2020 and others.

Please click on "Next" button to start the consultation.

***Respondent's details***

| Item | Response |
|---|---|
| First Name | |
| Last Name | |
| Position | |
| Organisation | |
| Type of stakeholder | • University/research organisation<br>• Industry – Semiconductor Manufacturing<br>• Industry – Semiconductor Materials<br>• Industry – Semiconductor Installations/ Equipments<br>• Industry – Semiconductor Design<br>• Industry – Applications<br>• Policy maker<br>• Investor<br>• Other (please specify) |
| Email address [to receive the outputs of public consultation] | |

***General***

**1. Please rate on a scale 1 to 9 the importance of the following policy areas for the competitiveness of the European semiconductor clusters.**

| Policy area | 1 (hardly important) | 2 | 3 | 4 | 5 (somewhat important) | 6 | 7 | 8 | 9 (highly important) |
|---|---|---|---|---|---|---|---|---|---|
| State aid | | | | | | | | | |
| Tax incentives | | | | | | | | | |
| Favourable trade conditions | | | | | | | | | |
| Pre-commercial public procurement | | | | | | | | | |
| Access to finance | | | | | | | | | |
| Public-private partnerships | | | | | | | | | |
| Other means | | | | | | | | | |
| R&D&I capacities (including education and training programmes) | | | | | | | | | |
| Effect of innovation policy and industrial policy regimes | | | | | | | | | |
| Technology transfer from research organisations and universities to companies within and between semiconductor clusters | | | | | | | | | |
| Technology transfer between the semiconductor manufacturing companies and different application customers | | | | | | | | | |
| Cluster organisations | | | | | | | | | |
| Potential for new clusters or further networking | | | | | | | | | |

***State aid***

| **2.1 What adjustments in *State Aid* policy would allow for increasing the competitiveness of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
|---|
| o Allow Member States to offer competitive benefit packages comparable to aids in other regions of the world.<br>o Extend the focus of State Aid on key areas to prevent part of the semiconductor value chain from disappearing from Europe (e.g. manufacturing)<br>o Increase support for key semiconductor sectors in Europe (e.g., materials)<br>o Simplify the (legal) procedure for granting State Aid in Europe<br>o Other (please specify) |

| **2.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Tax incentives***

| **3.1 What adjustments in *tax* policy would allow for increasing the competitiveness of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
|---|
| o New or adjusted R&D tax credits<br>o New or adjusted 'tax holidays'<br>o New or adjusted indirect tax incentives (GST, VAT, CST etc.)<br>o Other (please specify) |

| **3.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Favourable trade conditions***

| **4.1 What adjustments in *trade* policy would allow for increasing the competitiveness of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
|---|
| o Eliminating new tariffs on emerging semiconductor devices<br>o Non-discrimination for foreign products in all markets<br>o An end to investment restrictions tied to technology transfer requirements<br>o Zero duties on multi-chip packages<br>o Reduction of tariff and non-tariff barriers<br>o Removal of impediments to e-commerce<br>o Elimination of copyright levies on digital products<br>o Passage of the pending Free Trade Agreements<br>o Other (please specify) |

| **4.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Pre-commercial public procurement***

| **5.1 What adjustments in *pre-commercial public procurement* policy would allow for increasing the competitiveness of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
|---|
| o More focus on public procurement activities from policy makers including funding for R&D&I<br>o Active (pre-commercial) procurement programmes that guarantee product adoption on the market<br>o Procurement catalogues (e.g., the government compiles a list of products which it can procure)<br>o Other (please specify) |

| **5.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Access to finance***

| **6.1 What policy measures need to be introduced to increase *access to finance* for the European semiconductors industry? Please select at least one of the options.** |
|---|
| o Increase access to Venture Capital<br>o Stimulate syndicated lending (i.e. lending of funds by a consortium of financial institutions)<br>o Other (please specify) |

| **6.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Public-private partnerships***

| **7.1 What adjustments need to be introduced to the policy on *public-private partnerships* in order to increase the competitiveness of the European semiconductor clusters? Please select at least one of the options.** |
|---|
| o Introduce more clear and streamlined rules applicable to the consortia agreements (e.g., rules regarding Intellectual Property (IP))<br>o Ensure that public-private partnerships go to higher Technology Readiness Levels (TRLs)<br>o Ensure that universities and research institutes are willing to collaborate and follow the needs of the industry<br>o Other (please specify) |

| **7.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

### *Other means*

| **8.1 What *other* policy measures need to be introduced to increase the competitiveness of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
|---|
| o Harmonisation of ICT standards and standardisation processes;<br>o Single market regulation;<br>o Market surveillance on unsafe products;<br>o Intellectual Property Regulation;<br>o Bonuses for cross border cooperation and dissemination;<br>o Enhancing semiconductor workforce (immigration policy);<br>o Advancing environmental initiatives;<br>o Upholding strong anti-dumping laws and effective anti-dumping remedies etc.;<br>o Other (please specify). |

| **8.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

### *R&D&I capacities*

| **9.1 What adjustments in policy would allow for boosting the current *R&D&I capacities* of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
|---|
| o Making micro- and nanoelectronics a priority educational objective and development theme, ranging from awareness in the primary-to-high school education followed by developing multi-disciplinary curricula in academic training<br>o Launching programmes and curricula at all levels able to raise innovation awareness dramatically and to attract both new students and teachers to all disciplines in the nano-/microelectronic sciences<br>o Large scale support from public authorities for structural investments in R&D&I facilities;<br>o Other (please specify) |

| **9.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Effect of innovation policy and industrial policy regimes***

| **10.1 What adjustments need to be introduced to *innovation and industrial policy regimes* to increase the competitiveness of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
| --- |
| o Promoting and leading international cooperation<br>o Encouraging the creation and expansion of new firms in high-technology sectors<br>o Calling on financial markets and venture capital investment capabilities<br>o Leveraging the 'institutional' capabilities that academia (universities and research institutes) and regional and local government bodies provide to extend and exploit their research infrastructures such as science parks, incubators, venture partnering, etc.<br>o Creating incentives for clusters etc.<br>o Other (please specify) |

| **10.2 Please elaborate on your answer in the box below.** |
| --- |
| [open question] |

| **11.1 Specifically, what measures are needed to effectively support semiconductor *manufacturing* in clusters? Please select <u>at least one</u> of the options.** |
| --- |
| o Encouraging end-use industry base<br>o Reaching standard agreements quickly and effectively<br>o Launching cross-industry cross-border initiatives<br>o Other (please specify) |

| **11.2 Please elaborate on your answer in the box below.** |
| --- |
| [open question] |

***Technology transfer from research organisations and universities to companies within and between semiconductor clusters***

| **12.1 What policy measures are needed to effectively support technology transfer from universities to industry at the individual level (scientists)? Please select <u>at least one</u> of the options.** |
|---|
| o Funds for labour-mobility work<br>o Allowing part-time positions<br>o Public funds for collaborative research<br>o Revenue sharing rules<br>o Funds for entrepreneurship<br>o University patent legislation<br>o Other (please specify) |

| **12.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |
| **13.1 What policy measures are needed to effectively support technology transfer from universities to industry at the institutional level (universities)? Please select <u>at least one</u> of the options.** |
| o Benchmarking exercises<br>o Funding policies (e.g., public funding for SMEs to acquire technologies from universities)<br>o University patent legislation<br>o Other (please specify) |

| **13.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Technology transfer between the semiconductor manufacturing companies and different application customers***

| **14.1 What new/adjusted measures are needed to stimulate the technology transfer between the semiconductor manufacturing companies and different application customers? Please select <u>at least one</u> of the options.** |
|---|
| o Direct business alliances or partnerships between semiconductor companies and |

- application companies
- Centres of excellence based on common interests and complementary capabilities
- Other (please specify)

| **14.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

***Cluster organisations***

| **15.1 What role should *cluster organisations*[359] play to stimulate the competitiveness of the European semiconductor clusters? Please select <u>at least one</u> of the options.** |
|---|
| o Networking (institutional networks, seminars, workshops, conferences on scientific and business issues, social events, newsletters)<br>o Providing information/signposting (websites, company directories, port of call for inward investors, company visits)<br>o Articulating needs/lobbying (interaction with local government, interaction with national government);<br>o Collaboration/joint action (purchasing consortia, equipment sharing schemes, mutual access to libraries, access to legal expertise/documentation)<br>o Education/training (seminars/workshops on specific topics, e.g. regulatory issues, marketing, business development; encourage training institutions to put on courses)<br>o Cluster promotion (attending trade fairs/conferences, organising conferences, partnering events with overseas companies, presentations for local companies)<br>o Access to technological platforms/ scientific equipment<br>o Other (please specify) |

| **15.2 Please elaborate on your answer in the box below.** |
|---|
| [open question] |

[359] Cluster organisation implies organised efforts to facilitate cluster development, which can take various forms, ranging from non-profit associations, through public agencies to companies. A cluster organisation typically functions as a mediator between various cluster members and adds value by stimulating collaboration both within the cluster and between the cluster and the outside world.

*Potential for new clusters or further networking*

| **16.1 What policy measures can effectively stimulate the *emergence* of new semiconductor clusters?** |
| --- |
| [open question] |

| **16.2 Please elaborate on your answer in the box below.** |
| --- |
| [open question] |

| **17. What policy measures can effectively stimulate *collaboration* of semiconductor clusters?** |
| --- |
| [open question] |

*Other remarks*

| **18. Please provide your other remarks in the box below (not compulsory).** |
| --- |
| [open question] |

European Commission

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