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Abstract: The preparatory briefing on Taiwan is the result of the collection of relevant cluster information in the country, including business and sector trends, cluster policies and programmes, as well as a cluster mapping. This document is intended to provide an overview of the country's opportunities for European cluster organisations and SMEs

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1 Objective of the report

The aim of this preparatory briefing is to provide up to date information on the cluster landscape in Taiwan, China in order to support European cluster organisations and their SME members to familiarise with the country and explore its potential for collaboration and market opportunities. More specifically, this briefing paper provides an overview of the country's economy and sectoral trends/strengths where clusters contribute. In addition, it outlines the existing cluster community, the cluster policies, local support to clusters and the cluster programmes - including their historical development and internationalisation activity where they apply.

A complementary a discussion paper is available that provides an overview on the existing EU-Taiwan cluster cooperation, presents related good practices/success stories and opportunities for future exchange, including recommendations for an EU-Taiwan cluster policy dialogue (non-public information).

The content of this report is sourced through desk research and confirmed by relevant Taiwanese stakeholders.

2 Taiwan Economy: focus on sectoral trends

2.1 Overview

In 1960 decade, Taiwanese economy was marked by a surge of economic growth, as backed by the United States of America (US) and for a high demand for Taiwanese products, such as agricultural and textile good[1]. Throughout the 1970s, Taiwan started its transition to heavy industry and infrastructure, spurred by a cut back in US aid. The massive technological development experienced along the next 20 years, along the globalisation process in Asia and around the world, led to a shift in the economic structure towards a high-tech industry and service-oriented model[2].

In the late 1990s, Taiwan economy became one of the so-called Four Asian Tigers, together with South Korea, Hong Kong and Singapore. While Taiwan and South Korea became major global manufacturers in several sectors, Hong Kong and Singapore transformed into major financial centres.

Largely driven by industrial manufacturing, and exports of electronics, machinery and petrochemicals, Taiwan has become the 22nd largest economy worldwide. It is considered to be a *mostly free* economy, ranking 13th in the world and 5th in the Asia-Pacific region due to its success in business freedom, fiscal health and high government spending, according to the 2018 Index of Economic Freedom[3]. Its relatively well-developed commercial code and open-market policies facilitate the flow of goods and capital, enabling small and medium-size enterprises (SMEs) to become the backbone of Taiwan's expansion. A sound legal framework protects property rights and upholds the rule of law. Thus, Taiwan offers a stable economic and political environment for business and other similar endeavours.

Trade between Taiwan and the European Union (EU) has almost doubled in the last ten years, from €27,967 million in 2009 to €50,148 million in 2017[4]. The imports are composed mostly of machinery and appliances, base metals, transport equipment, plastics and rubber and optical and photographic instruments. On the other hand, the EU exports to Taiwan consist of machinery and appliances (semi-finished), transport equipment, chemical products and similar, optical and photographic instruments and foodstuffs, beverages and tobacco.

Similar to trade, the EU investment in Taiwan has steadily increased over the past years. The EU Foreign Direct Investment (FDI) to Taiwan reached €12 billion in 2015 and it became the largest foreign investor in 2016[5]. However, the EU is still impaired by trade barriers that make access to the Taiwanese market difficult, especially in some sectors such as agriculture.

[1] Wu, T.M. (2004) "A Trade History of Taiwan"
[2] "The Story of Taiwan - Economy", www.taiwan.com.au/Polieco/History/ROC/report04.html
[3] The Heritage Foundation, "2018 Index of Economic Freedom", www.heritage.org/index/country/taiwan
[4] European Commission DGfor Trade, http://ec.europa.eu/trade/policy/countries-and-regions/countries/taiwan
[5] Taiwan's Ministry of Economic Affairs (MoEA), Investment Commission, www.moeaic.gov.tw

The EU supports the involvement of Taiwan in multilateral discussions, where Taiwan's participation is considered relevant to the EU and global affairs. Furthermore, the EU and Taiwan have cultural and commercial relations and an ongoing dialogue that enhances and expands their ties.

2.2 Opportunities for Europe – investment, trade and science, technology & innovation cooperation

The EU and Taiwan authorities have collaborated for many years with very successful outcomes. So far, the cooperation was mainly economic, focusing on investment and trade. Nevertheless, both partners intend to strengthen their bonds by further exploring potential areas of common interest, which are expected to bring mutual benefits in shared challenges.

Taiwan is the 22nd largest economy in the world, with a GDP of €551 billion in 2017. Agriculture accounts for 1.8% of the total GDP, manufacturing represents 36% and services the remaining 62.2%[6]. The Taiwanese economy is recovering after a severe slowdown during the 2008 financial crisis, due to the constriction of global trade and the decreasing of crude oil prices (two of its most relevant markets) followed by a new crisis caused by the regional volatility in 2009 and 2016. Since 2016, Taiwan's GDP has been growing at an approximate average rate of 2% annually, lifted by better performance of the global economy, the buoyant demand for semiconductors and the rise of raw materials prices.

Described as a high-income economy by the World Bank (WB) with a GDP per capita of €20,314 in 2017, Taiwan ranked 34th (out of 195 countries) in terms of income[67]. The private consumption statistics have shown an improvement after the economic crisis, which caused a decline in salaries and the falling-off of revenues associated with the reduction of mainland tourists. Currently, Taiwanese citizenship enjoys one of the highest incomes worldwide and the government is very committed to implementing measures towards wealth equality.

According to the Global Competitive Index 2017-2018, Taiwan ranked 15th (out of 140 countries) rebounding for the first time after several years of decline, only topped by Singapore, Hong Kong and Japan in Asia. In the same line of many regional advanced economies, including the aforementioned, Taiwan profited from the favourable macroeconomic context and the regional market stabilisation[8].

Geo-economically, Taiwan is a strategic entryway to China's massive market and the Association of Southeast Asian Nations (ASEAN), with which the current Taiwanese administration intends to promote further integration through the "New Southbound Policy" (2017)[9]. In addition, Taiwan's foreign reserves in gold and foreign currency (USD) are the world's sixth largest.

The EU is the main foreign investor in Taiwan economy and the Taiwan is the 5th biggest trade partner of the EU from the Asia-Pacific region[4]. Therefore, trade and investment are the primary focus of cooperation between the regions. They are actively supported through working groups, regulatory

[6] National Statistics, Republic of China (Taiwan), https://eng.stat.gov.tw/mp.asp?mp=5
[7] World Bank (WB), www.worldbank.org
[8] The Global Competitiveness Report 2017-2018, www.weforum.org/reports/the-global-competitiveness-report-2017-2018
[9] Ministry of Foreign Affairs (MoFA), https://nspp.mofa.gov.tw/nsppe/

dialogues, seminars and workshops, such as the "3rd Industrial Policy Dialogue" or the "Green Summit: Moving towards a circular economy and sustainable trade", both held in 2017.

As a matter of fact, while the EU trade with the world decreased by 1.9%, from 2015 to 2016, it increased by 3.9% with Taiwan in the same period[Erreur ! Signet non défini.]. In this respect, statistics also show the EU is progressively tackling the existing trade deficit with Taiwan. Between 2007 and 2017, EU exports to Taiwan increased by 35.7%, while imports from Taiwan only increased by 11.5%.

Taiwan is considered by specialists a preferred destination for FDI due to the economic dynamism, the high purchasing power of the population and the high-tech sector growth. According to the A.T. Kearney's FDI Confidence Index, Taiwan ranked as the 15th most attractive economy for FDI worldwide and the 4th in the Asia-Pacific region (2016)[10]. The 2018 Doing Business Ranking elaborated by the World Bank ratified this by ranking Taiwan 15th with the most attractive business environments[11].

As abovementioned, the EU is one of the largest investors in Taiwan, with the Netherlands, United Kingdom, France and Germany leading the way (2016). Nonetheless, for environmental and security reasons, Taiwan is closed for investment in some industries such as natural gas, telecommunications, mass media, public utilities, and air and sea transportation. On the Taiwanese side, in 2016, 59.3% of its total FDI was directed to China with the EU only receiving 2.4%, although the flow to the EU has been gradually increasing since 2013[Erreur ! Signet non défini.].

In addition to trade and investment, the EU and Taiwan authorities also cooperate in science, technology and innovation (STI). The EU innovation policy is currently guided by the Framework Programme H2020 (2014-2020), which as its predecessors, aims at supporting and fostering research within the EU, as well as encouraging the participation of third countries in those initiatives considered of global interest. In parallel, since 2003 Taiwan supports and co-funds national researchers that wish to participate in research and innovation (R&I) programmes promoted by the EU.

The EU and Taiwan economies face similar challenges in spite of size differences so a series of priorities for cooperation have been established, namely: personalised healthcare and medicine; digital security; smart cities and communities; competitive low-carbon energy; energy efficiency; and blue growth, with special emphasis in unlocking the potential of seas and oceans. As of 2016, there were 21 active EU projects in which Taiwanese partners were involved[12].

The limited internal market makes Taiwan highly dependent on trade and FDI, exposing the Taiwanese economy to fluctuations in global demand. Taiwan is also facing increasing competition from the Chinese and Asian Pacific markets where the signs of a productivity slowdown, suggest the need to focus on advancing technological readiness and innovation in these markets. Taiwan economy must continue a high level of innovation to stay competitive. The low birth rate, stagnant wages, rapidly aging population, outflow of talent, and diplomatic isolation are other major long-term challenges.

[10] The 2016 A.T. Kearney's FDI Confidence Index (Taiwan does not appear in the 2017 Index), www.atkearney.com
[11] Wolrd Bank (WB), Doing Business 2018, www.doingbusiness.org/rankings
[12] European Economic and Trade Office (EETO), EU-Taiwan Factfile 2017, https://eeas.europa.eu/delegations/taiwan_en

2.3 Sectoral strengths

The Taiwanese administration announced the "5+2 Major Innovative Industries Policy" in 2016[13]. The programme provides a framework to pursue a domestic reform meant to develop and diversify the Taiwanese economy into a more modern, innovative and energy efficient model. Besides promoting the expansion of trade with more advanced economies that could reduce its exposure on China market, Taiwan also intends to address internal challenges such as the shortage of talent, the low investment in R&D and the amendment of existing regulations that stand in the way of industrial transformation.

To achieve this, the plan calls for investments on infrastructures, promotes research labs, and proposes to foster through funds and capital-access the R&D SMEs' strategies in seven sectors considered of strategic importance for advancing the progress of Taiwan, namely: agriculture, biotechnology, circular economy, defence, green energy, internet of things (IoT), and smart machinery, **Erreur ! Source du renvoi introuvable.**.

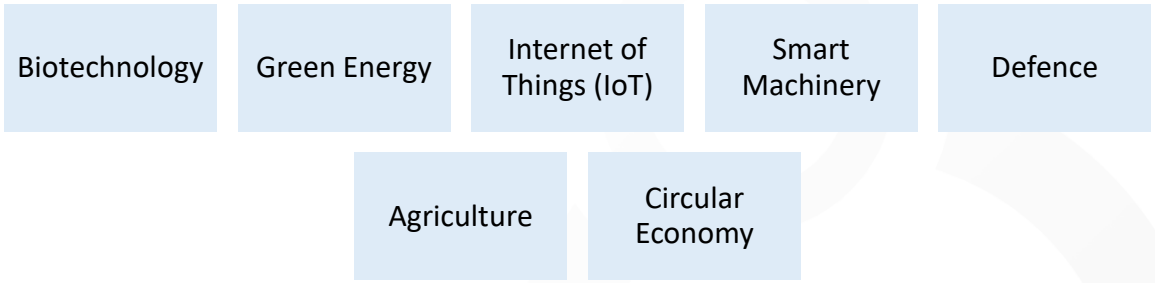

FIGURE 1 - STRATEGIC SECTORS IN "5+2 TAIWAN'S INNOVATIVE INDUSTRIES POLICY" PLAN

The programme was then broadened to include the Digital Economy and Cultural Innovation, as well as Semiconductors and IC Design, although the name remains the same. The plan will be backed by the government's NT$100 billion (€2.75 billion) Industrial Innovation and Transformation Fund to be used for investment in new technologies, with another NT$10 billion (€275 million)[14] from the recently established National Investment Corporation.

All in all, the "5+2 Major Innovative Industries Policy" aims to shift Taiwan's industrial base away from its traditional concentration on contract manufacturing and gear it towards high-value-added, service- and solutions-oriented business models. The plan envisions the result as spurring innovation, job creation, and more equitable wealth distribution. Thus, it demonstrates the willingness of Taiwan to work closely with regional and global partners, which together with its favourable business environment, offers significant opportunities.

[13] Taiwan Business Topics (AmCham Taipei), https://topics.amcham.com.tw/2017/05/52-industrial-innovation-plan
[14] Oanda, N$1= €0,03 , 31st of December 2016

Due to its synergies with the European Commission (EC) strategy for the near term and the EU industrial cluster community, the fields that seem to offer more potential for cluster cooperation between the EU and Taiwan related to the industries listed above are: information and communication technologies (ICT), smart machinery, biotechnology and, renewable energies, especially wind off-shore.

Agriculture, defence and circular economy are not to be ignored since they are also very relevant for the EU. However, agriculture and defence present more obstacles for third countries to enter in the Taiwanese market at the present moment.

2.3.1 Information and Communication Technology (ICT)

Taiwan is the largest ICT products manufacturer worldwide. The steady growth of the industry, which accounted for 16.6% of the total GDP in 2014[15], is mainly driven by public incentives such as easing regulations, creative financial mechanisms to boost investment and the recruitment of talent.

Taiwan's approach to developing the ICT sector was modelled after Silicon Valley in California (US) in order to create a high-tech industrial park able to attract multiple companies that produce different ICT products. Thus, the Asia Silicon Valley Development Plan (2016) aimed to help transform Taiwan's industries and build new engines for economic growth through: promoting Internet of Things (IoT) technology and innovative entrepreneurship; and focusing on new application services including mobile lifestyle, artificial intelligence (AI), automated driving and piloting, augmented and virtual reality (AR/VR), and IoT information security[16].

The National Development Fund (NDP) earmarked NT$100 billion (€2.75 billion)[17] for an industrial transformation fund intended to shift Taiwan from contract manufacturing towards innovation and smart technology. The fund injected NT$1 billion (€27.5 million) in operating capital into social enterprises. It also approved NT$1 billion (€27.5 million) for a business angel investor programme in support of start-ups. The national investment firm Taiwania Capital Management Corp. provides additional funding**Erreur ! Signet non défini.**.

The objective is to build an innovation and entrepreneurship ecosystem capable of attracting and developing high-skilled talent, as well as to act as a venue to foster innovation, encouraging the creation of new high-tech business. In addition, Taiwan is promoting smart city demo sites focusing on the areas of smart transportation, smart health care and IoT application platforms.

The first S&T policy dates from 1959, with the "Guidelines for the Long-Range Development of Science" and the establishment of the National Science Council (NSC). In 2014, the NSC was upgraded to Ministry of Science and Technology (MoST). Another key institution in Taiwan's ICT landscape is the Institute for Information Industry (III), established in 1979. The III conducts several activities that include: organising think tanks for the ICT industry; promoting ICT applications; fostering academia-

[15] Directorate-General of Budget, Accounting and Statistics
[16] NDF), Executive Yuan, «Asia Silicon Valley Development Plan for industrial transformation» (2017), https://english.ey.gov.tw/News_Hot_Topic.aspx?n=58F0F1B08BA63877&sms=21D7639DF54C05F6
[17] Oanda, NT$1 = 0,03€, 31st of December 2017

industry cooperation, and with international partners; providing ICT training; and organising R&D activities across multiple disciplines related to ICT[18].

It does not come as a surprise that Taiwan is home to the first world wireless city. The 2007 Broadband Access to Every Village was launched by the National Communications Commission (NCC). The project aimed at providing broadband service in 100% of Taiwan's territories, while the government pushed the counties to offer opportunities to learn how to use computers and Internet[19].

As it is well known, the Taiwanese Semiconductor industry is quite large. The Taiwanese Semiconductor Industry Association (TSIA) represents almost 71% of the worldwide Integrated Circuits (IC) foundry revenue, 55.5% of global package and testing revenue, and 19.4% of worldwide design revenue. In 2016, including design, manufacturing, packaging, and testing, the Taiwan Semiconductor Industry totalled NT$2,449.3.0 billion (€72 billion)[14.] By the end of that year, it consisted of 240 IC fabless design houses, 16 fabrication companies, 37 packaging and testing houses, seven substrate suppliers, 11 wafer suppliers, three mask makers, and four lead frames companies.

Even though the figures are already impressive, the Taiwanese semiconductor industry is forecasted to grow over 7% annually as developments of IC devices for Artificial Intelligence of Things (AIoT) gain momentum, boosting demand for IC design, manufacturing, and packaging and testing services, according to the Industrial Economics and Knowledge Center (IEK)[20].

Taiwan is also a powerhouse concerning consumer electronics, although retail volume and sales of consumer electronics in Taiwan continued to decline in 2017. In fact, wearable electronics was the only category that experienced positive growth. The foremost factors influencing this trend are related to slow economic growth, weaker consumer confidence and stagnant wage levels.

The tightening of household expenditure and negative consumer sentiment has led consumers to restrict their spending on discretionary items, yet different demographics have distinctive consumption behaviour patterns, especially within consumer electronics. In addition, the increase in the domestic and international competence is becoming more challenging[21].

In this context, the Taiwanese ICT industry, alongside smart manufacturing, is focused on the development of IoT and AI. In the first case, predictions estimate that IoT will reach an annual growth rate of 17% at a global level and that more than 75 billion devices will be connected by 2025[22]. Consequently, Taiwan will emphasise the production of IoT hardware, software, services and connectivity. In the case of AI, not only does Taiwan lead the world in contract semiconductor manufacturing, but it is also the top producer of ICT in terms of volume. The extensive adoption of

[18] Institute for Information Industry (III), https://web.iii.org.tw
[19] National Communications Commission (NCC), www.ncc.gov.tw
[20] www.taipeitimes.com/News/biz/archives/2017/11/13/2003682151
[21] www.euromonitor.com/consumer-electronics-in-taiwan/report
[22] Ferry, T., "The Internet of Things Arrives in Taiwan – Taiwan Business TOPIC"

technology within vertically integrated application areas (e-health, smart cities, e-government, smart manufacturing, etc.) permits Taiwan to construct complete smart systems.

This will transform Taiwanese industry, with the hardware sector exerting an economic push and the software sector a complementary pull that will help secure opportunities and advantages as the next wave of the smart-tech revolution builds, propelling Taiwan into the next stage of economic development as it emerges as a smart digital island[23].

2.3.2 Industry 4.0: Smart Machinery

Smart machines consist of manufacturing equipment that is intelligent, self-learning, and can communicate with other machines and human operators, transmitting data in real time. Building in its outstanding ICT capabilities and manufacturing value chain, Taiwan enjoys a privileged position when it comes to harnessing all the potential lying in the application of these advanced technologies in almost every industry.

Taiwan is the seventh largest exporter of machine tools and components worldwide**Erreur ! Signet non défini.**. By 2016, it averaged €3.8 billion in exports per year, from the past three years, with more than 1,000 precision machinery manufacturers and 10,000 downstream suppliers[24]. Moreover, the manufacturing industry contributed 30.8% of the total Taiwanese GDP in 2017, and still grew at an impressive 4.4% rate (MoEA, 2017). Lastly, Taiwan machinery industry's annual output is valued at about NT$1 trillion (€27.5 billion) by the Taiwan Association of Machine Industry (TAMI).

The goal is for the Taiwanese industry to move beyond the manufacturing of precision machinery, in which it already excels and where it has a major exposure in the world market, into the realm of smart machinery. This would allow the industry to gain flexibility responding to market demands, thereby strengthening the international competitiveness of the sector. According to Chaney Ho from Advantech, the Taiwanese manufacturing industry is striving to transform by four steps: full automation, data collection, data integration and cloud analysis[25].

To accomplish this, it is estimated that between 2017 and 2020 over €16.7 million will be invested in the Central and Southern Taiwan Science Parks, creating new employment opportunities and boosting turnkey production line/plant exports, so that different sectors can increase their productivity and consolidate Taiwan's manufacturing position internationally[26]. The "Smart Machinery Industry Promotion Plan" (2016), prioritises the introduction of smart machinery into large manufacturers and SMEs, developing smart machinery applications in the manufacturing and ICT industries[25].

The Programme includes the following strategies:

[23] National Development Fund (NDF), Executive Yuan, « AI Taiwan Action Plan—Transforming industry with artificial intelligence » (2018) https://english.ey.gov.tw/News_Hot_Topic.aspx?n=D53925F50550A904&sms=4037A32CDEF1DDCF

[24] PR Newswire, "Taiwan to Announce New Industry 4.0 Projects at IMTS 2016", www.prnewswire.com/news-releases/taiwan-to-announce-new-industry-40-projects-at-imts-2016-300322354.html#

[25] Chaney Ho, President of Advantech (Taiwanese company), http://blog.aac.advantech.com/four-steps-of-the-manufacturing-transformation?hsFormKey=b50c86b618a5b73f493c4229f4f11131

[26] "Taiwan Key Innovative Industry – Smart Machinery" MoEA

Connecting locally

Taichung is the centre of the Taiwanese precision industry and as such, it has been selected as the location for developing a global smart machinery cluster. The available resources will be integrated along with the capacity of academia and research organisations in developing the cluster.

Connecting with the future

In response to unfolding trends, efforts will focus in developing advanced technology and establishing systematic solutions capacity. In addition, field trials will be conducted to verify operability in preparation for export of systems integration solutions.

Connecting with the world

Smart machinery sector exchanges with Europe, the US and Japan will be enhanced, advanced technologies from abroad will be introduced, and cooperation with major international manufacturers will be promoted. The ultimate goal is to transform Taiwan into a global smart machinery R&D and manufacturing base.

The global market for smart machinery was worth US$7.4 billion (€7 billion)[14] in 2016, and is expected to grow 15% annually to reach US$15 billion (€12.5 billion)[Erreur ! Signet non défini.] by 2021. The rate of growth is expected to increase after 2021 with a forecast of US$40 billion (€33.4 billion) by 2026, according to a study by the analytics firm BCC Research[27].

At the same time, the ICT industry keeps investing in the installation of smart automated production lines to improve productivity and maintain its global competitiveness. This opens a wide range of opportunities for EU clusters and businesses.

[27] Ferry, T., « Risen of the (smart) marchines » (2017), https://topics.amcham.com.tw/2017/05/rise-smart-machines

Erreur ! Source du renvoi introuvable. highlights some opportunities in the Taiwanese and Asian markets in smart machinery.

Smart Machine Tools

- Asian machine tool sector is worth US$50 billion (€41.7 billion)
- Taiwan's annual prodution value is US$4 billion (€3.3 billion)

Semiconductor Production Equipment

- Asian semiconductor market is worth US$31 billion (€25.9 billion)
- Taiwan's semiconductor market is work US$12 billion (€10 billion)

Intelligent Robots

- The global industrial robotic systems is worth around US$35 billion (€29.2 billion)
- It is expected from 2017 to 2019 the CAGR of the installation volume will be about 13%

Smart Manufacturing

- The global market for smart factories will exceed US$1.7 trillion (€1.4 trillion) in 2022
- Estimates show that the he CAGR will be aroun 9.3% per year

FIGURE 2 - SMART MANUFACTURING OPPORTUNITIES

2.3.3 Biotechnology for human health

Biotechnology for human health is one of the fastest developing fields in science and technology (S&T) and it constitutes one of the principal markets in Taiwan, obtaining revenues worth €8.5 billion in 2017[28]. With more applications than any other area, biotechnology can lead to improvements in medical and healthcare technology able to enhance human health to an unknown extent and presenting a vast potential from an economic standpoint.

To harness this potential, biotechnology was included in the "5+2 Major Innovative Industries Policy" as an important business sector that will help fuel the growth of Taiwan's next-generation industries. The sector has been receiving continuous institutional support since the early 1980s in the form of favourable regulations, policies, investment and infrastructure. This support provided with the

[28] Hu, Chin-Lung, « Overview of Biotechnology Industry in Taiwan, Biotechnology & Pharmaceutical Industries Promotion Office », 2017

ultimate objective of raising the output value and competitive capabilities of the biotechnology industry, and positioning Taiwan as the hub of biomedical R&D in the Asia-Pacific region[29].

To achieve this purpose, the government launched the "Biomedical Industrial Innovation Promotion Programme" to function as the new blueprint for innovative biomedical research and development (R&D). In addition, the government passed a draft amendment to the "Act for the Development of Biotech and New Pharmaceuticals Industry" (2016).

The programme included four action plans to accelerate the industrial growth: build a comprehensive ecosystem (talent and capital, topic selection and intellectual property, law and resources); integrate innovative clusters; connect global market resources; and, promote specialised key industries by indorsing niche precision medical services, fostering clusters of world-class specialty clinics, and developing industries in health and wellness.

Since the biotechnology sector is rather broad, it can be divided in three sub-sectors, namely: applied biotech, pharmaceuticals, and medical devices. While applied biotech and medical devices reached a 9% compound annual growth rate (CAGR) in the past ten years, accounting for 29% and 45% of the benefits obtained by the sector, respectively; pharmaceuticals had a 2.2% CAGR and were responsible for 26% of the profits[30]. Overall the industry experienced a 5.7% CARG from 2007 to 2017, increasing its profits from €5.1 billion in 2007 to the €8.5 billion in 2017.

The Ministry of Science and Technology (MoST), the Ministry of External Affairs (MoEA) and the Ministry of Health and Welfare (MoHW), as well as the Council of Agriculture (CoA), were the main bodies involved in the promotion of biotechnology, providing the means for companies to jumpstart their product development at a minimal cost[31]. As a result, the biotechnology sector was able to gradually complete its value chain, from the upstream core facilities needed for R&D to technology transfer, research institutes, clinical trial infrastructures, commercialisation and industrialisation.

Taiwan enjoys several advantages over its neighbours, that mainly relate to the already heavily developed high-tech sector, which is easily transferable to biotechnology, and the numerous R&D infrastructures planned to foster national talent that could meet the demands of the high-tech industries. Presently, the Taiwanese biotech firms have a combined market capital of €19 billion[32].

The approval of both generic and new drugs is expected to accelerate the growth of the pharmaceutical industry to 7.6% CARG in the period 2015-2020. Taiwanese firms are involved in both the production of conventional "small molecule" pharmaceuticals as well as the development of cutting edge "large molecule" biological drugs derived from cells. Currently, there are 220 new drug pipelines under different stages of development in Taiwan.

[29] Executive Yuan, Republic of China (Taiwan), 2016 https://english.ey.gov.tw
[30] Su, J., Chang, S., « Taiwan Healthcare Sector, Credit Suisse AG », 2017
[31] Introduction to Biotechnology and Pharmaceutical Industries in Taiwan, Rep. of China MoEA
[32] Taiwan Biotech Industry is Heating Up Amcham, https://amcham.com.tw/2016/04/taiwan-biotech-industry-heating-up/

Given the long trials and costly basic research required by biomedicine, the development of medical devices is another field where many opportunities will arise due to the less time-consuming manufacturing process and short-term profit. Other interesting areas are caregiving for elderly population, prevention and treatment technologies for major illness, precision medicine, gene and cell therapy, technologies and products for preventive and regenerative medicine, health management service models based on preventive healthcare needs and health foods.

Overall, the prospects for the biotechnology sector in the coming years are very optimistic. Taiwan is creating a biomedical corridor running from north to south and in 2017, the government established a new venture capital firm, Taiwania, to provide long-term and large-scale investment in basic research. The goal is to achieve breakthrough growth in the output value of pharmaceutical products, medical equipment, and the health and wellness industry, driving annual growth rates from 6% to 9% by 2025. In addition to driving economic growth and promoting health and wellbeing, these efforts will make biomedicine a paradigm for the next generation of innovative industries in Taiwan[29].

2.3.4 Renewable Energy

Taiwan imports 97.5% of its energy, which makes the transition to renewables a key step to secure its energy supply and independence[33]. In the scope of the "5+2 Major Innovative Industries Policy", the Industrial Innovation Programme for Green Energy Technologies (2016), aims to help transform the Taiwanese energy structure and increase the generation of electricity from renewable sources to a 20% share in 2025[34], so that Taiwan embraces energy security, environmental sustainability, and a green economy.

In order to fulfil this purpose, the programme will promote green energy tech industries while driving Taiwan's energy transformation and economic development. It focuses on energy generation, storage and conservation, and systems integration. The programme will also include several initiatives such as a solar and wind energy promotion plan, a nationwide Green Energy Roofs project launched in 2017[35], and a pilot programme for smart meter installation.

In 2016, the authorities set out to install three million smart meters by the year of 2026**Erreur ! Signet non défini.**. Plans took off in 2017, with the objective of having a smart grid that supports Taiwan in coping with fluctuating power sources and improving energy generation, storage and conservation. Other Asian economies such as China, Japan and Korea are promoting the smart grid as a means to ensure energy security.

Currently under development, the Shalun Green Energy Science City initiative is also to be highlighted. The objective is to establish an advanced facility that serves as the future home of an industrial

[33] « Taiwan green shift defies energy security fears » Financial Times

[34] National Development Fund (NDF), Executive Yuan « Energy transformation: Industrial innovation for green energy technologies» (2018) https://english.ey.gov.tw/News_Hot_Topic.aspx?n=59DEADADC8768A6B&sms=BC2B3196A2DFE029

[35] National Development Fund (NDF), Executive Yuan, « Green Energy Roofs project: Solar panels on every rooftop » (2017), https://english.ey.gov.tw/News_Hot_Topic.aspx?n=76D79F4BEA1158D5&sms=DB1AA370D75B8DD1

innovation cluster linking the business, academia and research, which will function as a R&D hub and demonstration site for Taiwan's clean energy tech industries[36].

The Renewable Energy Development Act (REDA, 2009) aimed at increasing the renewable energy capacity of Taiwan. The Act consists in a mix of incentives and obligations, whose ultimate goal is to expand the renewables capacity from 4.3GW, in 2015 to 27.4GW in 2025. In addition, there are also plans to reduce the dependence of fossil fuel energies and phase out nuclear power by 2025.

In an effort to reduce the carbon emissions to 20% of the 2005 levels by 2030**Erreur ! Signet non défini.** at the same time as reducing its nuclear power exposure, the Taiwanese government will invest heavily in windfarms (offshore) and solar installations, which not only have environmental advantages, but are perceived as an opportunity to attract tech giants. Taiwan is the second largest manufacturer of solar photovoltaic panels in the world since 2008, but instead of engaging in a price competition with the China market, Taiwanese producers are looking forward to develop a more efficient photovoltaic cell production.

Taiwan seeks to foster innovation through the liberalisation of the electric power market. By reducing the monopoly control of the state-owned Taiwan Power Co. (Taipower), the government seeks to stimulate competition in the electricity power market and promote entrepreneurial initiatives, which will lead to innovation and improvements in the sector.

In 2017, the amendments to the Electricity Act allowed independent green power producers to sell their power directly to consumers and not only to Taipower. Also in 2017, the biggest producers (NeoSolar, Gintech and SolarTech) announced their merger, strengthening the Taiwanese solar panel manufacturing industry. Moreover, Motech announced its plans to build a solar farm extending its role in the value chain from manufacture to power generation[37].

In 2018, to gradually replace nuclear power with green energy, the "Thousand Wind Turbines Office" (MoEA) awarded grid capacity to 11 offshore wind projects to be set up in three phases in 2020, 2021 and 2025. This not only sets Taiwan on track to highly increase its offshore wind capacity by 2025, but turns the island into a focus point for the world's top offshore wind developers that seek a foothold in Asia[38]. In fact, companies from Germany and Denmark led the competition.

The goal for 2030 is to install 4200 MW units of wind power: 1200 MW units onshore and 3000 MW units offshore[39]. Among the promotion strategies to boost these numbers were the Feed-in Tariff (FIT) for onshore and offshore wind, the Offshore Demonstration Incentive Program (DIP), which aimed at implementing three demonstration wind farms by 2020 and the Zonal Development, that conciders 23 industrial areas for offshore wind farms[40].

[36] National Development Fund (NDF), Executive Yuan « Energy transformation: Industrial innovation for green energy technologies» (2017), https://english.ey.gov.tw/News_Hot_Topic.aspx?n=A8A56944A0458D4B&sms=0064637C15D6B84F
[37] Energy Trend, www.energytrend.com.tw/news/20170906-14308275.html
[38] www.offshorewind.biz/2018/04/30/taiwan-selects-eleven-offshore-wind-projects/
[39] Wang, Y.K. "The Overview of Taiwan Wind Power Industry"
[40] www.mofa.gov.tw/Upload/RelFile/2508/111034/25bcd458-67d7-4ed4-994b-128a7ba49d17.pdf

The phase out of nuclear power is, however, experiencing some drawbacks. Currently, Taiwan has three functional nuclear plants (Chinshan, Kuosheng and Maanshan) and one under construction, which represent six nuclear reactors operable and two advanced reactors under construction. Nonetheless, the construction of the fourth nuclear plant was suspended and almost all the other reactors were ceased by Tsai's administration, which stands for a non-proliferation policy[41].

Although, the Taiwanese society has supported this posture for a long time, the non-proliferation movement gained new strength after the 2011 Fukushima disaster in Japan, which highlighted the risks of using nuclear energy in a region prone to earthquakes and other natural hazards.

In spite of this, together with the pressure to cut carbon emissions and coal-fired plants, the rapid decommissioning of nuclear power seems to be related to the alarming pollution of the air and a dangerous shortage of energy. In response, the Taiwan's Atomic Energy Council (AEC) approved in 2018 a plan to restart the nuclear power plant reactor number 2 after 600 days of shut down[42]. This decision aims to reduce the vulnerability of Taiwan and neutralise the unhealthy conditions resulting from the uptick in coal production accompanying the nuclear phase out, without having achieved the required development of renewable energies.

Event though, a strong opposition is expected, this disposition can also be seen as a shift in the prevalent perspective towards nuclear power, showing a more serious consideration of the advantages related to using nuclear power in the overall strategy to go green[43].

In the transportation sector, Taiwan is committed to banning the sale of fossil fuel powered motorcycles and cars by 2035 and 2040, respectively. The government is providing incentives for green transport, through tax exemptions for purchases of electric vehicles, while the National Development Fund is funding green projects such as Gogoro, an electric scooter manufacturer.

Aware of the challenges that will face its energy grid during the transition, Taiwan is taking the necessary measures to ensure a smooth shift towards green energy by increasing investments and incentives in order to motivate private companies and entrepreneurs to deploy projects in Taiwan. It is also working to harmonise the regulations and standards in energy, to withdraw barriers and to improve third party certification (Four-year wind power promotion plan to create clean energy).

Thus, green energy offers enormous potential for EU business growth since Taiwan expects to attract investment from foreign manufacturers in the areas of blades, gear boxes, and power generators for offshore wind power turbines; power systems, chassis systems, and whole vehicle systems for electric vehicles; as well as converters and storage system for photovoltaic energy.

[41] www.world-nuclear.org/information-library/country-profiles/others/nuclear-power-in-taiwan.aspx
[42] www.taiwannews.com.tw/en/news/3377170
[43] https://thediplomat.com/2018/03/taiwans-nuclear-dilemma

3 Cluster community in Taiwan

3.1. Cluster mapping

The concept of cluster in Taiwan is different from the European one, although a certain propensity towards a common model can be observed. The Taiwanese clusters develop from a science or industrial park established to fulfil the needs of a strategic sector and dynamise the regional economy. They are mainly composed of SMEs, the business backbone of Taiwan, to which other organisations such as research centres, universities or incubators gradually join. On the other hand, given the deep specialisation of Taiwan high-tech industry and the role of large businesses, industrial associations play a special role in invigorating international collaboration through clusters.

This duality proves a strong feature in the Taiwanese cluster landscape as the most dynamic large companies can spearhead a number of breakthroughs alongside with EU SMEs in clusters. In particular, as it comes to international cluster cooperation, the role of industrial associations has become more apparent and indeed active. When the two dimensions would come together the potential for EU-Taiwan cluster cooperation will reach new heights.

Since 1970, Taiwan's economy has been hand-in-hand with the development of industrial parks. Initially, due to the rapid establishment of industry, factories were set up all over Taiwan. The absence of a planning strategy, as well as the lack of plant sites in adequate locations, caused factories to establish in random locations that resulted in an inability to effectively use and control the resources.

To solve this situation, the Industrial Development Bureau (IDB), MoEA, created a development team in 1970 for planning and organising the use of industrial areas. During the next decade, the development of industrial parks was carried out in coordination with the economic development plans and after the 1990s, the industrial park model changed towards the diversification of specialisations, which upgraded the industrial development by establishing the archetypal industrial park, as it is known presently[44].

The establishment of science and industry parks is considered a central policy measure to spur growth. Therefore, building on the institutional setup and supported by financial incentives, clustering becomes a natural evolution in this process, aimed at supporting regional potential by encouraging horizontal and vertical cooperation among universities, SMEs and large firms through transfer of knowledge and diffusion of technology[45].

Taiwanese companies are clustered in science and industrial parks that have evolved in a particular region and which are engaged in manufacturing or service provision involving special local products

[44] www.moeaidb.gov.tw

[45] Hasan S., Klaiber H.A., Sheldon, I., «Regional innovation policy in Taiwan and South Korea: The impact of science parks on small and medium-sized enterprises' productivity distributions» (2015)

with particular historic or cultural significance, or uniqueness, making use of local materials, natural resources, traditional handicraft techniques, and local labour[46].

To simplify the cluster analysis and mapping, Taiwan is divided into three regions: Northern Taiwan, Central Taiwan and Southern Taiwan. Following this, the distribution of industrial clusters in Taiwan can generally be broken down into electronics and technology in the north, precision machinery in central region, and petrochemicals and heavy industry in the south. Nevertheless, the landscape is rapidly changing with the upgrading to new technologies in all fields.

Table 1 breaks down the regions into their respective cluster and sector:

TABLE 1 - CLUSTERS AND THEIR SECTORS PER REGION[47]

Region	Cluster	Sector(s)
Northern Taiwan	Hsinchu Science Park & Yilan Science Park	ICT
	Jhunan Science Park	Biotechnology and ICT
	Longtan Science Park	Green Energy
	Tongluo Science Park	Green Energy, ICT and Smart Machinery
	Nankang Software Park	ICT and Smart Machinery
	Nankang Biotech Plaza & Hsinchu Biomedical Science Park	Biotechnology
Central Taiwan	Taichung Science Park	ICT and Precision Machinery
	Chung Hsing Park & Huwei Science Park	ICT
	Houli Science Park & Erlin Science Park	Smart Machinery
Southern Taiwan	Tainan Science Park	ICT, Green Energy and Smart Machinery
	Kaohsiung Science Park	Medical Equipment and Smart Machinery

Nankang and Hsinchu Science parks, which are located in Northern Taiwan, are frequently seen as the engines that guided the development of Taiwan's high-tech companies. The Hsinchu Science Park (HSP) was established in 1980 to replicate the success of Silicon Valley by importing technology and talent to transform the domestic industry and help the Taiwanese high-tech industry take off[48].

[46] Small and Medium Enterprise Administration, MoEA, « 2017 White Paper on Small and Medium Enterprises in Taiwan » (November, 2017)
[47] The clusters are known by their anchor science park.
[48] Hsinchu Science Park profile. Accessed on 11/04/2018

The Nankang Software Park (NSP) and Nankang Biotech Plaza (NBP) are located in Taipei, in the Nankang District. Despite the NSP being relatively new, the park has a very important role in the Taiwanese economy due to its focus on software based start-ups. The NBP is considered a focal point for the biotech industry[49].

The Central Taiwan Science Park (CTSP) opened in 2003 in Central Taiwan. It is the newest of the science parks to be built in Taiwan. The parks within the CTSP include Taichung Science Park (Taichung City), Huwei Science Park (Yunlin County), Houli Science Park (Taichung City), Erlin Science Park (Changhua County) and Chung Hsing Park (Nantou County). The number of employees from the 189 companies in the parks reached 39,956, in 2016[50].

The Southern Taiwan Science Park (STSP) was approved by the government in 1995 and is composed of two parks: Tainan Science Park and Kaohsiung Science Park. The park is working closely with the government to promote the "5+2 Major Innovative Industries Policy", meaning it will continue to develop the green energy sector, upgrade smart biotech industries and foster innovation through R&D subsidies. Official projections see the STSP as accommodating 400 companies and 180,000 workers by 2021.

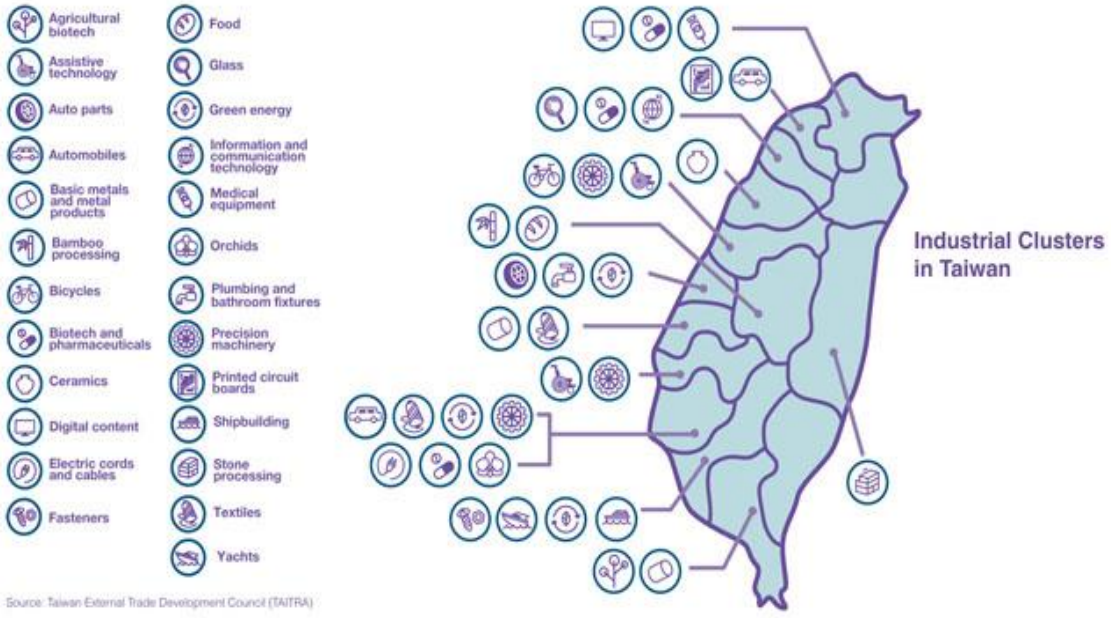

FIGURE 3 - OVERVIEW OF THE CLUSTERS IN TAIWAN[51]

[49] "Taiwan's Biotech and Pharmaceutical Industries", www.asiabiotech.com
[50] Central Taiwan Science Park profile.
[51] Source : Taiwan External Trade Development Council (TAITRA)

As can be observed in Figure 3, Taiwan's clusters are mainly located on the western part of the island due to the better transport infrastructure (i.e. better access to freeways, airports and ports/harbours) and the proximity to China, a central client of Taiwanese goods.

Figure 4 shows the main five strategic sectors of the "5+2 Major Innovative Industries Policy", including the ones analysed in the present document.

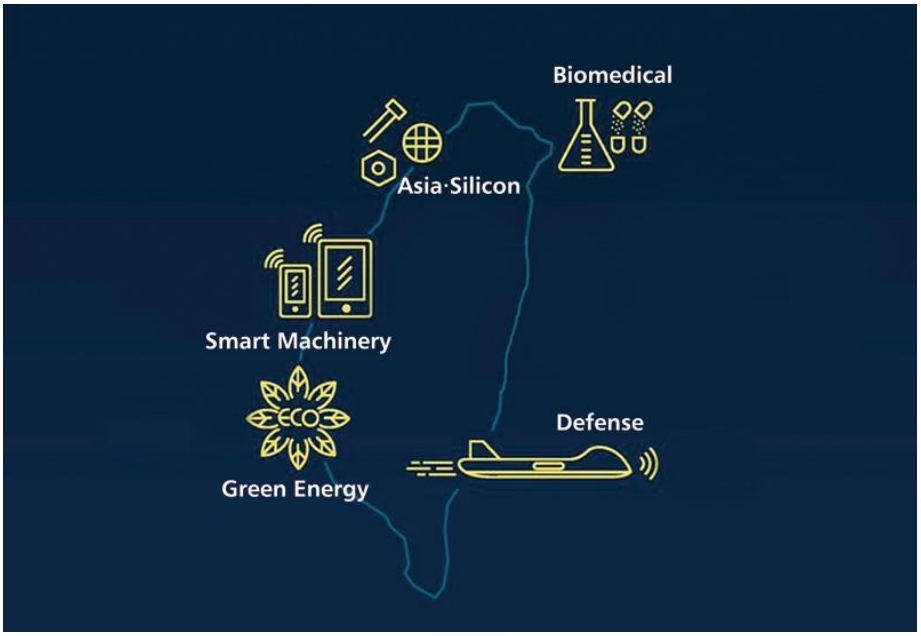

FIGURE 4 - "5+2 MAJOR INNOVATIVE INDUSTRIES POLICY" CLUSTERS[52]

[52] American Chamber of Commerce: https://topics.amcham.com.tw/2017/05/52-industrial-innovation-plan/

3.2 Clusters in Biotechnology, ICT, Renewable Energies and Smart Manufacturing

There are excellent examples of clusters within the sectors highlighted earlier by this briefing: ICT, smart manufacturing, biotechnology, and renewable energy. The following clusters are a sample of those that exist in Taiwan.

ICT clusters

Hsinchu Science Park

The Hsinchu Science Park (HSP) was established in 1980 by MoST being the first of its kind. The objective was to replicate the success of Silicon Valley. As mentioned before, the HSP is now covering five more locations – Jhunan, Tongluo, Longtan, Yilan and Hsinchu (Biomedical). For the past three years, HSP companies posted an annual average of more than NT$1 trillion (€3 billion)[Erreur ! Signet non défini.] in revenue[60].

The park is heavily influenced by the Industrial Technology Research Institute, National Tsing Hua University and National Chiao Tung University with more than 50 of its companies having emerged as spinoffs from the aforementioned institutions. Moreover, the close interaction with academia has brought to HSP a very competitive workforce. There are more than 45,000 master degree holders and 3,900 doctorate degree holders working in the park.

Besides cultivating a number of high-tech talent, HSP also fostered global flagship ICT companies over the past three decades, for example:

- TSMC and UMC, the two largest IC foundry providers;
- CHIMEI INNOLUX and AUO, the third and fourth largest TFT-LCD makers, respectively; and
- MediaTek, the second largest mobile phone chipset maker and the third largest IC designer.

More than 70% of global IT industry products are initiated from companies at the HSP, which has been able to attain high-tech investments as well, as drawing international attention. In addition to being a cluster of industrial ventures from the ICT sector, the HSP stimulates R&D on the science and technology front, cultivates talent and brings prosperity to local communities.

Nankang Software Park

The Nankang Software Park opened in 2003 in Taipei City. Since then, a large number of enterprises have established themselves in this facility. Currently, it is home to about 253 local and foreign high-tech companies, i.e. IBM, Yahoo, Sony, Intel, Microsoft or Hewlett-Packard.

The firms established in Nankang benefit from access to funding and from high-class infrastructure. In fact, the park has all the elements for the development of a comprehensive innovation system, including support from government agencies, and the presence of the necessary research institutes

and enterprises. The presence nearby of many leading universities and research facilities has also contributed to its consolidation[53].

Nankang facilitates the diffusion of knowledge and ideas, the formation and cementing of collaborative partnerships, and ready access to funding. The cluster effect has helped to reduce operating costs and to strengthen R&D capabilities, enabling firms to transform knowledge into products with significant commercial value.

The Nankang Software Park, alongside the HSP, is credited for being the catalyst of the development of the high-tech industry in Taiwan and as such, it has received multiple recognitions from international media agencies regarding the strong impact within the high-tech sector. Estimations indicate that Nankang will produce revenues valued in $US28 billions (€27,4 billion)[Erreur ! Signet non défini.] and will employ over 28,000 workers.

Smart Manufacturing clusters

Taichung Science Park

The Taichung Science Park is part of the Central Taiwan Science Parks. Home to the core Taiwanese manufacturing industry, it aims to become the foremost cluster in smart machinery, and the driver of the sector's development. For instance, Taiwan intends to transform the park into a "smart machinery metropolis"[54]. The establishment of the Smart Machinery Promotion Office in Taichung, promoted by the Smart Machinery Promotion Programme (MoEA), the Industrial Development Bureau (IDB) and the Precision Machinery Research and Development Center (PMC), was a big step in this direction[55].

The Office will assist the transition of manufacturers into Industry 4.0 and its principal objectives will be to establish a local talent pool, accelerate innovation in the industry, and help manufacturers expand sales and distribution channels. Likewise, the participation of more than 28 universities in the Office will promote the academia-industry cooperation through the integration of the R&D and know-how from the academia to the business[56]. Additionally, universities will provide the required talent, with professionals already familiar with digitization and smartification technologies in different industries, and will provide experienced employees the opportunity to update their knowledge.

The office will also incorporate resources from government agencies, research institutes and the private sector to accelerate smart machinery R&D, so Taiwan can gradually wean itself off reliance on foreign imports. Especially in high-end component assembly, system applications, and services. As a consequence, it is expected a boost in the domestic market that facilitates local manufacturers to invest and eventually shift towards smart manufacturing.

[53] SME Industry Clusters – Cluster Innovation and Strategic Development
[54] Industrial Development Taiwan, Industrial Development Bureau, MoEA, 2016
[55] www.twmt.tw/taiwan-launches-smart-machinery-promotion-office-in-taichung
[56] Crafting with Precision – Taiwan Today, www.taiwantoday.tw/news.php?unit=8,32&post=120702

Taichung is expected to be completed by 2019 and attract around €2 billion in investment.

Kaohsiung Science Park

The Kaohsiung Science Park belongs to the Southern Taiwan Science Park. The cluster emerged after China Steel Corp. initiated its activity in the 1970s, attracting SMEs and other businesses in the supply chain, ranging from equipment manufacturers to processing plants. Currently, the cluster houses almost half of the 1,500 industries in the sector and plays a key role in the international competitiveness of Taiwan in manufacturing.

Aiming at establishing a southern technology corridor, Kaohsiung integrates the Nanzih Export Processing Zone, the Kaohsiung Multi-Functional Commerce & Trade Park, the Kaohsiung Software Industrial Park, and the Pingdong Export Processing Zone. Furthermore, the cluster counts on the strong support of Kaohsiung City Government, which jointly with the Yanchao University, plans to construct an R&D centre for high-tech industries in southern Taiwan.

The main industries in Kaohsiung are semiconductor, precision machinery, optoelectronics, computers and peripherals and telecommunications. In fact, it is home to the Telecommunications Technology Centre, which started to operate in 2004 and functions as an R&D organisation whose objective is to attract upstream and downstream telecommunication companies.

By 2020, the estimated revenues are expected to reach NT$500 billion (€14 million) and the cluster will employ around 52,000 people[57]. Together with Tainan, the Kaohsiung Science Park will receive an investment (to be determined) to create opportunities in the AI and robotics industry[58].

Biotechnology clusters

Hsinchu Biomedical Science Park

The Hsinchu Biomedical Science Park (HBSP), part of the Hsinchu Science Park (HSP), is one of the biggest projects in Taiwan. The park is a knowledge, innovation and incubation-oriented science park, whose ultimate goal is to form an industrial cluster in biotechnology. Currently, there are 33 companies established in the park.

Established in 2003, the HBSP acts as a powerhouse for cultivating domestic innovation and industrialisation in biotechnology by connecting universities, research institutes and companies. Among its infrastructure, it includes the Hsinchu Biomedical Science Park Hospital, the Biotech and Product R&D Centre and the Industry and Incubator Centre[59][60].

HBSP was built following the one-stop shop concept to support Taiwan's transformation into a well-known biotech hub by means of technological added-value and industrial development in the

[57] https://taiwantoday.tw/news.php?unit=8&post=120698
[58] "MoST unveils plan for robotics production base" Taiwan Today
[59] www.hbmsp.sipa.gov.tw/BIOWEB/indexE.htm
[60] Hsinchu Science Park Bureau, MoST, www.sipa.gov.tw

advanced medical devices and pharmaceutical fields. The function and facilities of the overall park cover infrastructure, healthcare, talent, commerce and industry, and industrial services. Providing a business platform and a clinical trial network, while also encouraging the sharing of resources and the exchange of knowledge, reduces R&D and commercialisation costs and raises the success rate for biomedical science start-ups.

Efforts are being made to attract renowned international players and research centres to the park, and to harness the strengths of the ICT industry in the nearby Hsinchu Science and Industrial Park. The integration of HBSP within the HSP network, eases the access to services and stakeholders within other sectors, namely ICT, triggering the development of new biomedical technology.

Nankang Biotechnology Park

The Nankang Biotechnology Park is part of the Nankang Software Park (NSP). It is the cluster for domestic biotechnology and pharmaceutical R&D companies, where core research is conducted in biomedical translation and chemical biology, including biotechnology new drug, new reagent, and new vaccine development[61].

As of March 2016, there were 58 biotechnology and pharmaceutical companies, as well as science and research institutions established in the cluster, including manufacturers in new drug development, food biotech, medical testing, agricultural biotech, special biotech and biotech services. In addition, Academia Sinica and the Ministry of Economic Affairs' Small and Medium Enterprise Administration have also set up a dedicated biotechnology incubation centre to assist the creation and development of start-ups.

By joining the R&D results from Academia Sinica with inter-disciplinary teams within Nankang, the R&D results focus on biotechnology new drug development and are linked to existing medical centre research results in the greater Taipei area and clinical trial energy, expanding the cluster effect. With Academia Sinica and the National Institutes of Health stationed within the Nankang Software Park, along with Biotech Centres, existing academic research institutions, medical centres, and research-driven pharmaceutical companies, mutual cooperation and assets are strengthened, technology promoted, and clinical trials and product development carried out. The research results can be transformed by the cluster into social value, thereby accelerating the construction of Taiwan's cutting-edge industry as well as promoting the overall development of the country.

Nankang intends to join the biotechnology and pharmaceutical industry's important core upstream, midstream, and downstream unit. Furthermore, it serves a leading role in the support of Taiwan's biotechnology and pharmaceutical industry development policy.

Renewable energy clusters

Longtan Science Park

[61] www.biopharm.org.tw

The Longtan Science Park, still under development, is a part of the HSP. As of 2018, the park accommodates companies like AU Optronics Corp., Wafer Works Corp. and HIROSE Tech Co. that work in the green energy industry. The park's goal is to house companies within the renewable energy sector, more concretely optoelectronics ventures and those spanning the entire spectrum of the solar energy industry.

Tainan Science Park

The Tainan Science Park was the first park of the Southern Taiwan Science Parks. Established in 1993, it was part of an Economic Revitalisation Plan launched by the government, which intended to build a sustainable energy cluster in the Tainan City area. The objective was to facilitate the coordination among equipment suppliers, ICT businesses and energy service providers. Ultimately, the cluster would foster the creation of local business specialised in green energy system integration.

The park mainly houses companies from the optoelectronics and green energy industries. In this line, there are firms in various fields such as solar cells, solar systems and wind. It gathers around 150 companies and more than 45,000 employees of which, 18,000 work for Chi Mei Optoelectronics Corp. (CMO).

The success of the park results from a mix of the coordination between the companies and the park's management, and the overall layout of the park that allows the different sectors to prosper. It is home to the world leading TFT panel (LCD panel) manufacturing chain.

4 Cluster policies and programmes in Taiwan

4.1. The cluster policy in Taiwan

Cluster policy has a long tradition in Taiwan. In 1989, the SMEA, MOEA, began to allocate resources to support the development of local industries, which over the years have focused on different aspects, from “Initial Development,” “Deepening,” to “Bright Spot”.

Given that 98% of the businesses that make up Taiwan’s industrial sector are SMEs, clustering has been encouraged by the government as a key strategy to maintain the competitiveness in the world market. By creating linkages along the value chain, clusters comprised primarily of SMEs are able to meet demands cost-effectively and quickly.

The role of Industrial Associations and likewise national bodies reflecting also larger or very dynamic high tech firms is also noticeable in the clusters landscape as for international cooperation with EU they have proved suitable 'gatekeepers' to access industry. Both stakeholders combined represent a unique opportunity for EU-Taiwan cluster cooperation.

As it can be seen in many countries, the government plays a key role in the promotion of clusters. The private sector does not have the capability to launch and maintain the necessary investment, as well as the power to implement a coherent development strategy; while the public sector can offer financial support and policy coordination in the long term.

The Corporate Synergy Development Centre (CDS)[62] is a core actor in the support and development of Taiwanese clusters. It was established in 1984 as a non-profit partially government-funded organisation, with the objective of strengthening the clusters across Taiwan and improving the negative image of Taiwanese products, to neutralise the Chinese competition.

Since its creation, the CSD has supported more than 194 clusters. However, it was not until 2003 that CSD really stood out thanks to its A-team strategy with the bicycle cluster from Taichung City. After sharp declines in the bicycle manufacturing, CSD intervened by gathering the local SMEs to rearrange the manufacturing process. This resulted in the exports values improving from US$583 million (€553 million) in 2003 to US$1.48 billion (€1.4 billion) in 2016[14].

Likewise, recognising the benefits of clusters, in 2008 the SME Administration (MoEA) introduced the “Plan for the Provision of Integrated Services to Support SME industry Cluster Innovation” in order to stimulate the development of clusters in key industries, promote industry cluster innovation and integration, and build an industry service network[63]. The Administration anticipated that the adoption of cutting-edge business models can help to drive the growth of industry clusters and that the

[62] Corporate Synergy Development Centre (CSD), www.csd.org.tw

[63] Foghani, S., Batiah, M., Rosmini, O., « Promoting Clusters and Networks for Small and Medium Enterprises to Economic Development in the Globalization Era” (2017), http://journals.sagepub.com/doi/full/10.1177/2158244017697152

combination of horizontal and vertical integration will make it possible to achieve differentiation, helping SMEs to develop new market opportunities.

In 2009, the Executive Yuan established the Local Industry Development Fund to promote local economic prosperity by providing funding assistance in line with the development needs of local industries, and approved the Council for Economic Planning and Development (CEPD) overall plan for the i-Taiwan 12 Projects. The plan called for a total spending of NT$3.99 trillion (€11.21 billion), including government spending of NT$2.79 trillion (€78.4 billion) and private investment of roughly NT$1.2 trillion (€33 billion), during the 8-year implementation period from 2009 to 2016[14]. A total of 12 prioritised infrastructure projects were carried out during this period, including the development of new high-tech industrial clusters in central Taiwan.

More recently, the government prioritised cluster creation in its "5+2 Major Innovative Industries Policy". A core component of the New Model for Economic Development, the initiative covers the biotech and pharmaceuticals, green energy, national defence, smart machinery and IoT sectors, as well as the circular economy and a new paradigm for agricultural development. Furthermore, it has launched calls for investments in R&D facilities, where clusters are already established. By placing R&D facilities and universities near parks, Taiwan expects the wealth and resources provided by the latter institutions will enhance innovation and R&D capabilities, build upstream-downstream value chain collaboration mechanisms, and develop the cluster ecosystem in general.

Lastly, the 2017 White Paper on Small and Medium Enterprises in Taiwan includes within its strategy for promoting operational excellence and innovation, a "Project to Promote SME Clustering and Accelerate Innovative Commercialisation", which aims to encourage the integration of industry clusters and application of knowledge services and operational innovation. Guidance offered through the programme in 2017 entailed providing assistance to SMEs on utilising a clustering approach to facilitate economies of scale, and favouring cooperation on joint innovation for products, service and operating models, thereby boosting overall industry value[Erreur ! Signet non défini.].

4.1.1 Information and Communication Technology policy and programmes

Taiwan is one of the world's leading producers of ICT products. Due to the strategic relevance of the sector, the Taiwanese government has elaborated various plans to upgrade the ICT industry.

In 2016, the Taiwanese authorities launched the Asia Silicon Valley Development Plan as part of the "5+2 Major Innovative Industries Policy" to reinforce the promotion of the software industry, given the solid position the ICT hardware industry has already attained. The objectives are mainly to promote innovation and R&D for IoT devices and applications and to upgrade Taiwan's start-up and entrepreneurship ecosystem. In other words, the Plan will transform Taiwan's industrial structure through IoT, and drive economic growth by means of innovation and entrepreneurship.

The four implementation strategies are[64]:

- Optimise Taiwan's start-up and entrepreneurship ecosystem by increasing talent supply, providing business expansion capital, and adjusting laws and regulations.
- Enhance linkages with renowned clusters worldwide by forging connections with the R&D capabilities of Silicon Valley and other global innovation clusters. In the meantime, actively participate in international standards formulation and certification of IoT related technologies.
- Build a complete IoT supply chain by integrating Taiwan's hardware advantages into software applications. It would also encourage the commercialisation of research findings from universities and research institutes.
- Construct diversified demonstration sites for smart products and services by establishing a quality internet environment, building diversified smart test beds, and developing applications based on smart logistics, smart transport and smart healthcare.

In 2017, Taiwan launched its 8-years Digital Nation Plan, Digital Nation and Innovative Economic Development Plan (2017-2025) known as DIGI+, to develop its high-tech economy and propel digitalisation among companies[65]. The programme has been carefully designed to reinvigorate and expand Taiwan's digital economy.

The main goals of DIGI+ are to increase Internet bandwidth, bridge the digital division between urban and rural areas, and raise Taiwan's position in the global information sector. This intends to help Taiwan to attain a digital economy valued at NT$6.5 trillion (€182 billion, 29.9% of GDP) and place the country among the top 10 in the world for information technology by 2025[66].

The MoST will launch a semiconductor "moonshot" programme in 2018 to boost core technologies for the intelligent edge computing industry. This four-year, NT$4 billion (€107 million) programme is expected to help Taiwan carve out "blue ocean" opportunities in edge computing by developing new semiconductor processes and designing advanced chip systems. The overall objective is to find breakthrough technologies for edge computing by 2022 and develop AI chips for a broad range of edge devices[67].

Interestingly enough, the MoHW was a pioneer in the use of ICT. The smart card (also known as IC Card), which contains all the patient medical information, the medical kiosks where patients can access a range of self-service options including registrations, payments and in certain cases access to health records, and telemedicine for remote areas are some milestones that preceed the implementation of the Electronic Health Record (EHR) in more than 500 hopsitals and 20,000 clinics.[68]. By proactively

[64] www.ndc.gov.tw/en/Content_List.aspx?n=90BEB862317E93FC
[65] https://english.ey.gov.tw/News_Hot_Topic.aspx?n=93F8D0110C9255F5&sms=0AD2E2418479587D
[66] www.enterpriseinnovation.net/article/egov-conversations-taiwans-digital-nation-plan-1872933308
[67] https://english.ey.gov.tw/News_Hot_Topic.aspx?n=E172652AE3C7F847&sms=D41099B1FAA418BE
[68] www.it.is.tohoku.ac.jp/~kato/workshop2009/04.pdf

introducing cutting edge health information technology, the Taiwanese government aims to create world-class e-health services able to deliver quality medical care[69].

4.1.2 Industry 4.0 policy and programmes

In September 2015, the Executive Yuan approved Productivity 4.0, two four-year "Executive Chamber Productivity 4.0 Development Programme", which started in 2017 and will be implemented until 2024. An advance plan was launched in October 2015 and finalised at the end of 2016.

The objective was to achieve the goals of industrial transformation via breakthroughs in core technologies and value-added industries in addition to creating a new generation of competitive products for enhancing Taiwan's international competitiveness. Three major areas are envisaged to achieve Productivity 4.0: key technologies, the A-Team model and talent cultivation.

The government is planning to spend NT$36 billion (€97 million) over the next nine years as part of its Productivity 4.0 project. With the foundation of precision machinery and ICT technologies, Taiwan is implementing Productivity 4.0 to make smart machines a reality and promote the industrialisation of smart machines and smart machine-intensive industry.

As a consequence of the industrialisation of smart machines, Taiwan will be able to foster smart machine technologies, develop solution-based smart machines and establish a smart machine ecosystem. On the other hand, the smart machine-intensive industry will result in: reduced labour expenditures, accelerated talent recruitment, innovative production processes, increased productivity, and utilised ICT advantages to smarten up industry supply chains[70].

In order to develop the IoT technology, the MoEA signed a memorandum of cooperation with Microsoft in October 2015, combined with more than 30 domestic manufacturers to set up a centre for the development of IoT industries, focusing on manufacturing, medicine, home, intelligent retailing and public service.

The "5+2 Major Innovative Industries Policy", as first mentioned in section 2.3, aims to shift Taiwan's industrial base away from its traditional concentration on contract manufacturing and gear it towards high-value added, service and solutions oriented business models.

4.1.3 Biotechnology policy and programmes

The government has been investing in the biotechnology industry since 1984, aiming to convert Taiwan into a leading Asia Pacific region centre for biotech and pharmaceutical R&D. The investments intended to reinforce R&D capabilities, foster domestic talent, create incubators and industrial parks, adapt policies and regulations to harmonise with international standards and promote Taiwanese products and services to international markets. These actions led to an entrepreneurial and growing

[69] http://ehealthreporter.com/en/noticia/legacy-3368/

[70] Taiwan-Germany Productivity & Industry 4.0 Forum, 2016

biotech and pharmaceutical industry, with successful product launches, new innovative medical devices and medical management services, as well as a considerable overall progress in R&D.

To remain relevant in the market, the government is actively looking for trends in global biotechnology, seeking to identify priority areas. Furthermore, it has shown its willingness to revoke current barriers in the biotech market in order to attract international investment, and to encourage the creation of strategic alliances between domestic and international biotech firms.

In April 2005, the Executive Yuan launched its Biotech and Pharmaceutical Technology Island plan, which consisted of three major projects: the National Health Information Infrastructure, the Taiwan Biobank Database, and the establishment of a clinical trial and research system.

In March 2009, the governmental body announced the promotion of the Taiwan Diamond Action Plan for Biotech Takeoff. Priorities included strengthening technology acquisition capabilities, establishing biotechnology venture capital, promoting an integrated incubation mechanism, as well as setting up the Taiwan Food and Drug Administration (TFDA), so that the Taiwanese pharmaceutical regulation is better harmonised with the international standards[71].

Lastly, in 2016, the government approved the "Taiwan Bioeconomy Industry Development Plan". The objective is to go beyond the industrialisation of biotech and pharmaceuticals, adding value to other industries, namely: agriculture, drugs, food, healthcare and medical devices. The plan complements the "Productivity 4.0 Development Program" and the "Aged Society White Paper".

The Biomedical Industry Innovation Programme (BIIP), under the "5+2 Major Innovative Industries Policy" is a national initiative to develop Taiwan's biomedical industry. Jointly promoted by MoST, MoEA and MoHW; BIIP's mission is to enhance the health and wellbeing of the Taiwanese people and the world, while transforming Taiwan into the Asia Pacific's premier biomedical research and development hub through: improving the ecological system; integrating an innovative settlement; linking the international market resources; and promoting of key industries of special features.

The Biotechnology and Pharmaceutical Industries Promotion Office (BPIPO) administers Executive Yuan's one-stop service window for the biomedical industry, a single contact window designed to help companies receive a quick convenient service relating to any governmental or regulatory issues they might be facing. BPIPO is a friendly referral service for matters related to drug approval and other regulatory affairs, R&D applications, technology transfer and commercialisation, stock listings and investment promotion. The office helps companies to scale-up, offering consulting services, assistance in promotion activities, personnel training and recruitment, marketing, strategic alliances, as well as market information and other services.

[71] www.biopharm.org.tw/en/information_content.php?li=5

4.1.4 Renewable Energy policies and programmes

To achieve the vision of environmentally-friendly green energy, Taiwan is focusing on the integration of energy creation, energy storage and energy conservation through "smart" systems, to ensure that Taiwan has an industrial development environment free of energy shortages.

The government has put a strong effort on improving the environmental protection by formulating various energy-related acts concerning renewable energy and the mitigation of greenhouse gas emissions. These are the Renewable Energy Development Act, the Energy Administration Act Amendment, the GHG Emission Reduction and Management Act and the action plans since 2009. The main goal of the successive acts is setting targets for energy efficiency improvement, GHG emission reduction and renewable energy development.

In November 2015, the government submitted its Intended National Determined Contributions (INDCs) to the United Nations Framework Convention on Climate Change, committing to reduce Taiwan's GHG emissions by 50% from the BAU (business as usual scenario, i.e. if there were no intervention) by the year 2030, or roughly 20% lower than 2005 levels.

In 2016, the MoEA announced the New Energy Policy, which is meant at phasing out nuclear energy by 2025 and increasing the share of renewables in electricity generation to 20%. The New Energy Policy aims to achieve energy efficiency, reduce carbon emissions, and ensure power supply stability and sustainability. The energy industry reform strategies are the following[72]:

- Achieving the goal of a nuclear-free Taiwan by 2025;
- Actively developing green energy and increasing the share of renewables in total electricity generation to 20% by 2025;
- Accelerating the construction of Taiwan's third LNG receiving terminal, and expanding the use of natural gas; and
- Completing the revision of the Electricity Act to facilitate energy transformation.

In 2017, the Taiwanese government, in an effort to promote solar power, approved a plan to subsidise 40% of construction costs and 100% of design costs of residential rooftop solar panels installed from 2018 until 2020. The incentive also includes the construction of power stations in remote areas, and the compromise to purchase the excess of energy generated. The subsidy could reach up to NT$600,000 (€16,860).

Offshore and onshore wind power is also drawing a lot of attention. The government is calling for extensive investments in offshore windfarms. In 2018, Taiwan conducted an offshore windfarm auction to add 3.8 GW of grid capacity to its existing network of 8 MW. The offshore wind market is expected to expand to 5.5 GW by 2025, in a three stage process[73].

[72] www.moea.gov.tw/mns/ietc_e/content/Content.aspx?menu_id=21511

[73] www.reuters.com/article/us-taiwan-windpower/offshore-wind-power-firms-see-taiwan-as-a-battleground-to-expand-in-asia-idUSKBN1I11IV

5. Conclusion

The Taiwanese clusters are the main engine of the economic growth and international competitiveness of Taiwan and its different regions. Driven by market demand and government policies, the cluster community is rather mature and clearly oriented towards the global industry trends and its more sophisticated developments. The role of SMEs and start-ups alongside with large corporations, which is mirrored by the role of clusters organisations in science parks and in industrial associations, suggest the potential for EU-Taiwan cluster cooperation is deeper and has a broader scope than the one currently being exploited.

The World Economic Forum's "Global Competitiveness Report 2017" ranked Taiwan's "State of Cluster Development" second best in the world. Taiwan offers sound industrial supply chains that can meet client needs, offer fast responses and quickly provide customised components. In terms of quality and quantity, the competitive nature of Taiwanese products is a major reason why foreign investors choose the island as an investment destination.

The highly developed nature of its industrial clusters has helped Taiwan to become the world's second-largest information hardware producer, its semiconductor foundry industry and semiconductor packaging and testing industry to become top in the world, its Integrated Circuit design industry to become second in the world, and its Personal Computers products industry to become third[74].

In fact, Taiwanese SMEs, especially those that play an important role in the upstream supply chain supporting large enterprises' production and exports, are encouraged to form clusters in order to strengthen their competitiveness. Moreover, they are encouraged to focus on the trend of smart economy, which creates opportunities to innovate and start new business ventures through IoT and to upgrade through smart manufacturing by enhancing their competitive advantage in flexible production with customisation, rapid manufacturing, and creativity.

Therefore, the weight of the Taiwanese cluster community in the economy is enormous, accounting for an important share of the total industrial sector's revenues. Furthermore, clusters are the focal point of innovation and serve as a launching platform of key technologies that are essential for progress and growth. Nevertheless, the full potential of Taiwanese clusters is still to be exploited due to the recent shift from price to quality. This shift to quality will drive the need for greater R&D and the removal of existing barriers to foreign participation. The latest policies and programmes seem to consider a greater openness.

The majority of clusters can be traced in the western part of Taiwan, due to the better connective infrastructure and the proximity to China market. However, the government is using clusters to support regional development, and is promoting the articulation of corridors in the foremost industries

[74] https://investtaiwan.nat.gov.tw/showPage?lang=eng&search=5290

across Taiwan. Therefore, the importance of public policies is of great significance; nevertheless, clusters usually build from those parks that have already reached a stage of evolution that allows them to act as a coherent ecosystem.

The concept of cluster in Taiwan varies from the European one, but there is a tendency towards a common model. The EU and Taiwan share a common strategy in terms of emerging industries and future developments, placing their focus on ICT, Industry 4.0, biotechnology, and renewable energies. This presents a wide range of opportunities for cooperation in research, development, innovation, business development and trade. In this regard, EU clusters might bring technology centres into the collaboration; thus, deepening and expanding the existing bonds between both regions. The Administrative Arrangement on Cluster Cooperation, signed by the Taipei Representative Office in the EU and DG GROW of the European Commission, on the 6th of June 2018, is the most recent expression of both regions' efforts to continue cooperating.