sustainability

MDPI

Article

A Cross-Strait Comparison of Innovation Policy under Industry 4.0 and Sustainability Development Transition

Kuan Chung Lin [1,*], Joseph Z. Shyu [1,2] and Kun Ding [2]

1 Institute of Technology Management, National Chiao Tung University, No. 1001 Ta-Hsueh Road, Hsinchu 300, Taiwan; josephshyu@faculty.nctu.edu.tw
2 School of Public Management and Law, Dalian University of Technology, No. 2 Linggong Road, Ganjingzi District, Dalian 116024, Liaoning, China; dingk@dlut.edu.cn
* Correspondence: kuanchunglin@gmail.com

Academic Editors: Sang-Bing Tsai, Bin Liu, Yongjian Li, Yong Deng, Ming-Lang Tseng, Jih-Jeng Huang and Marc A. Rosen
Received: 26 March 2017; Accepted: 5 May 2017; Published: 9 May 2017

Abstract: While the advent of Industry 4.0 is emblematic of national strategy for industrial revitalization, the proliferation of technology has drastically changed the landscape of many major sectors of global industries. Industry 4.0 encompasses multi-dimensional concepts—including computerization, digitization, and intelligentization—of business operations based on cyber-physical-systems (CPS) and the Internet-of-Things (IoTs). The vision of Industry 4.0 will bring about improvements in industrial processes, ranging from engineering, material usage, supply chains, and product lifecycle management, to the horizontal value chain. This research project adopts a descriptive analysis with descriptive statistics under the innovation policy framework proposed by Rothwell and Zegveld. This report also informs a comparative policy analysis across China and Taiwan. From the perspectives of industry coalition and competition, this cross-strait comparison lends itself to being a policy-making reference. Results reveal that China, in terms of policy-making, concentrates on 'political' and 'legal/regulatory' aspects of environmental policy, as well as the theme of 'public service' of the demand-side policy. Taiwan also emphasizes the 'environmental-side' policy like China, whereas Taiwan focuses more on 'education/training' of the supply-side policy.

Keywords: Industry 4.0; innovation policy; cross-strait sustainability development; industry revitalization

1. Introduction

Industry 4.0 has attracted enormous attention from firms and governments in recent years. However, this conceptual idea has since been widely adapted by industrial nations such, as the U.S., German, EU, China, India, and other Asian countries. The vision of Industry 4.0 is supposed to bring about improvements from the industrial processes—including engineering, material usage, supply chains, and product lifecycle management—to the horizontal value chain [1].

WEF (World Economy Forum) reports reveal that "the fourth industiral revolution" will exert a significant impact on all industries around the world at a rapid speed, bringing about wide, comprehensive, and systematic transformations. In line with the Industry 4.0 programs, many nations have thus proposed different kinds of regulations or policies for the objectives of energy conservation, sustainability development, and industry transition. Germany is the preemptor for Industry 4.0 policy; followed by the U.S., which proposed the Advanced Manufacturing Partnership; China, which drafted China Manufacturing 2025; and Taiwan, which drew up Taiwan Productivity 4.0. Since Industry 4.0

will trigger the next wave of industrial competition, it is necessary for nations to arrange development strategies to confront incoming challenges.

From the technology side, the rapid emergence of AI, IoT, cloud computing, and big data facilitates knowledge proliferation and economic development. The cross-strait industrial chain reflects a complementary and integrated status after China's reform and opening of the 1980s. China and Taiwan are now both facing a transition stage of industrial transformation, revitalization, and 4.0 programs which will reshape the industry complementary structure. Literature related to Industry 4.0 mostly focuses on technology development, operation models, market trends, and case studies, and rarely on policy-making or transnational comparisons. This study tries to reveal the competition and coalition trend, and anatomize the cross-strait policy content on Industry 4.0.

Among all strategic issues of Industry 4.0, many researchers have focused on the communication systems [2], infrastructures, manufacturing processes [3], computer sciences, and other fields [4]. Policy or industry development-related studies are scattered and tend to overlook industry vertical integration [5], industry overview and development models [6], summaries of cross-nation Industry 4.0 policy goals and sub-industry execution projects [7], firm-level collaboration mechanism strategies [8], and even the context of Industry 4.0 development and industry transferring [9], but rarely are they specifically aimed at industry innovation policy and national policy. This study attempts to sketch the cross-national comparative policy analysis and innovation requirements to provide policy recommendations under Industry 4.0 for sustainable development. With policy analysis and pattern matching, we intend to deduce the competitive requirements for industry-level and nation-level policy suggestions.

2. Literature Review

2.1. Innovation Policy and Innovation Policy Model

Innovation is a critical element in the recent development of global industry. There are three aspects of industrial innovation, namely, the policy perspective toward innovation, the science and technology strategy of industrial innovation, and the business management perspective of industrial innovation. The interdependence and interactions of these three perspectives form a structure of nation's innovation systems, and the resulting sources of industrial leadership and competitive advantage [10].

Schumpeter (1934) defines innovation as the activity of developing an invented element into a commercially-useful element that becomes accepted in a social system [11]. Innovation is the use of new knowledge to offer a new product or service that customers want [12]. Therefore, innovation includes a series of activities: science, technology, organization, finance, and commerce. Innovation policy can be classified as demand-side-oriented or supply-side-oriented [13]. Similarly, theories on innovation process can be classified as linear or systems-oriented. Important parallels and logical connections can be drawn between these two classifications [14].

Policy analysis has traditionally been qualitative and descriptive. The concept of tools of innovation policy was first pioneered by Kirschen's [15], in which innovation policies are categorized into 64 policy tools. In the policy analysis by Schneider and Ingram [16], the researchers have summarized five types of policy tools, including authority tools, incentive tools, capacity tools, symbolic and hortatory tools, and learning tools. Other studies include descriptive analysis [17–19], cross-national comparative analysis [20,21], case studies [22,23], and qualitative evaluation techniques, such as innovation policy instruments [24]. The advantage of qualitative research is that it begins by accepting a range of different, legitimate industrial policies for industrial development.

Innovation policy includes science and technology (S&T) policy and industry policy. The making of industry policy is based upon demand-side consideration. Rothwell and Zegveld's [25] research summarized three dimensions with 12 innovation policy tools, which provide a concrete analysis tool for government support technology and innovation development on the national level. The policy framework examined in the study by Rothwell and Zegveld [26,27] summarized a categorization of innovation policies, including supply (public enterprise, scientific and technical, education, and information), demand (procurement, public service, commercial, and overseas agents), and environmental (political, legal and regulatory, taxation, and financial) policy tools [14].

This framework has been widely used in policy analysis [28–33] and covers the broader aspects and social collective benefits that innovation policy should consider. Figure 1 (adapted and simplified from [25]) shows the three main headings—supply side, demand-side, and environmental-side—are grouped by these policy tools and describe the policy target for innovation.

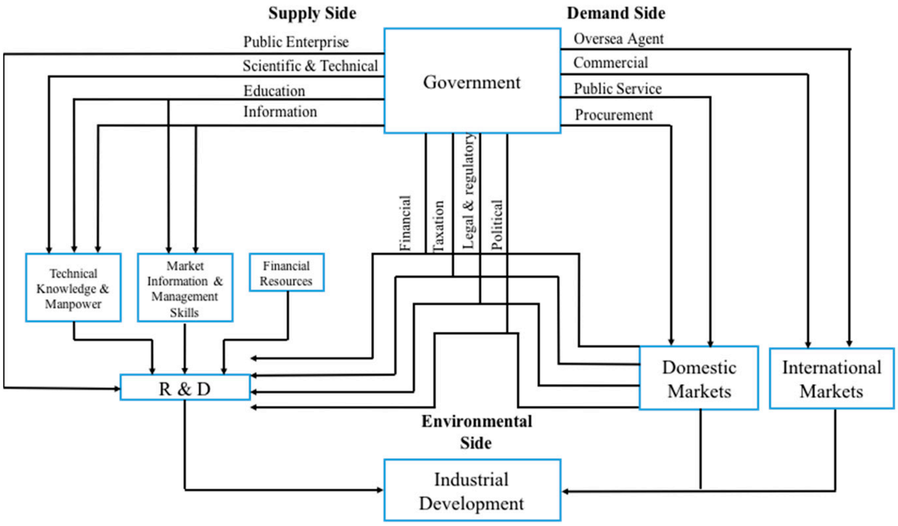

Figure 1. Policy targets and tools for promoting innovation. Source: adapted from Rothwell and Zegveld (1981).

To answer the research question concerning the comparative study of Industry 4.0 policies between China and Taiwan, we selected Rothwell and Zegveld's innovation policy framework as the policy category to analyze for China and Taiwan. The basic framework of this model is as shown in Figure 1. Rothwell and Zegveld classify policy instruments into three dimensions: supply side provision of financial, manpower, and technical assistance, including the establishment of scientific and technological infrastructure; the demand-side includes central and local government purchases and contracts, notably for innovative products, processes, and services; and the environment side focuses on taxation policy, patent policy, and regulations, i.e., those measures that establish the legal and fiscal framework in which industry operates. The following table shows the details and statements of this model.

The reason the present study selects this innovation policy framework, and why it may be useful in Industry 4.0 policy analysis compared with other innovation policy studies, can be elaborated as follows: (1) this two-level innovation policy structure offers a more comparable base of policy tools using an overall and systematic policy view. Industry 4.0 policies applied in different countries can clearly be categorized based on this supply, demand, and environment policy grouping. Future strategic suggestions for Industry 4.0 policy can also be based on the categorized framework; and (2) the framework of innovation policy was not generally designed for any specific industrial sector. According to our literature review, this framework has been widely used in comparable policy studies in different sectors, such as the electronics, semiconductor, and energy sectors.

2.2. Industry 4.0 Literature

Industry 4.0, in which computers and automation will come together in an entirely new way, with robotics connected remotely to computer systems equipped with machine learning algorithms that can learn and control the robotics with very little input from human operators. The smart factory is a core concept of Industry 4.0, which employs cyber-physical systems to monitor the physical production processes of the factory and make decentralized decision-making possible. Then the physical systems become the Internet of Things, communicating and cooperating both with each other and with humans in real-time via the wireless web. The development of Industry 4.0 will need inter-corporation value work horizontal integration and factory vertical integration. The incorporation of smart artifacts with wireless network, cloud, and mobile terminals will derive interdisciplinary knowledge and technologies integration [5].

Coupled with the progression of technology—including IoT, cloud computing, and AI—manufacturing industry intelligentization gradually matures because of rising labor costs and changing consumer behavior; however, the business model may be modified for matching this industry transition [34,35].

Generally, there are several key features about Industry 4.0 [36]:

1. Interoperability—machines, devices, sensors, and people that connect and communicate with one another.
2. Information transparency—the systems create a virtual copy of the physical world through sensor data in order to contextualize information.
3. Technical assistance—both the ability of the systems to support humans in decision-making and problem-solving, as well as the ability to assist humans with tasks that are too difficult or unsafe for humans.
4. Decentralized decision-making—the ability of cyber-physical systems to make simple decisions on their own and become as autonomous as possible.

These characteristics are basically used to describe the smart factory in Industry 4.0, and could be regarded as the features of Industry 4.0 because the interaction between the smart factory, equipment, infrastructure, and others is the core importance of Industry 4.0 [37]. Under Industry 4.0, the software sector also faces challenges, such as semantic data collection, correlation, and more complex amounts of data [38]. It is a revolution resulting from the convergence of industrial systems with advanced computing, sensors, and ubiquitous communication systems. Hence, the complexity of data and information collected from different devices, systems, and protocols make it essential to adopt Big Data principles. Technically, multiple technologies developed by Big Data—such as comprehensive data collection, storage, processing, and machine learning—are a critical aspect to achieving the Industry 4.0 vision [39–41].

Industry 4.0 is sometimes referred to as the fourth industrial revolution, and it is a vision of smart factories built with intelligent cyber-physical systems. The fourth industrial revolution concept has been adopted into government policy as the major idea around the world for industrial upgrades and transformation. From the 18th century, the invention of the steam engine kindled the first industrial revolution, with the machine replacing humans to become the main power resource at the time. Then, electric force popularization led to manufacturing process innovation, which made possible mass production and the capacity to ramp up to the second industrial revolution. The third industrial revolution benefits from information technology development in the 1970s which enhanced manufacturing automation and obliquely facilitated the rise of the Internet. Researchers and scientists believe that the Internet of Things, based on cyber-physical systems, will lead to the fourth industrial revolution.

The scope of the fourth industrial revolution includes electric and clean-tech vehicles, renewable energy, the smartgrid, IoT/IoE, Big Data, robotics, AI, fintech, blockchain, VR, cybersecurity, and agtech/agricultural innovation. These technologies are often deemed unrelated, but when they are joined together, they integrate the physical and virtual worlds. This change enables a powerful new way of organizing global operations: introducing the fungibility and speed of software to large-scale machine production. Cyber-physical systems, and the skills disruption that these systems bring about, are also associated with the fourth industrial revolution. IoT and CPS are what at stake in the fourth industrial revolution. The smart factory or smart something must build on the fitting of data processing, communication, and interaction between machines [9]. The Figure 2 below shows the product systems evolution from the first industrial revolution to the fourth [42].

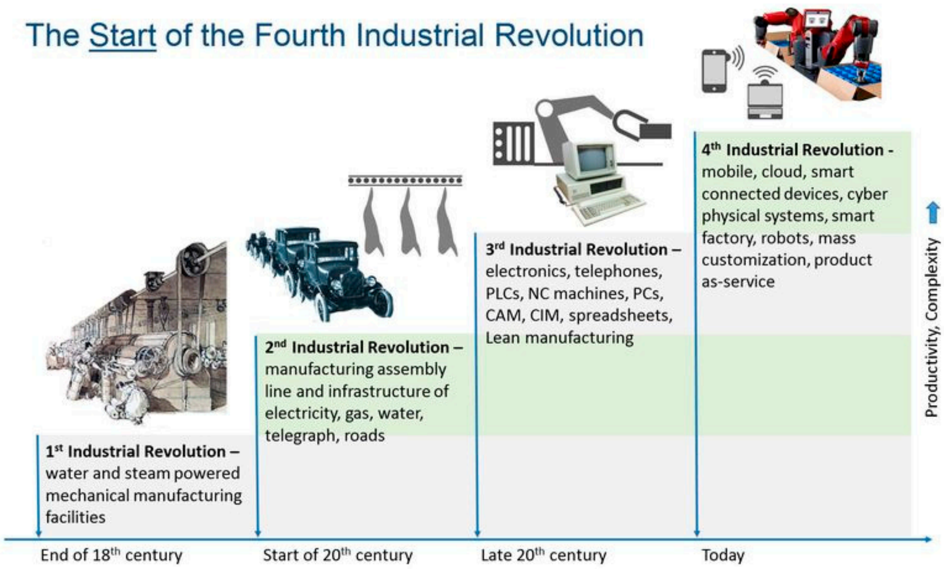

Figure 2. The four industrial revolutions. Source: John Moavenzadeh, 2015.

In 2016, PwC surveyed more than 2000 companies from 26 countries in the industrial production sectors, including aerospace and defense; automotive; chemicals; electronics; engineering and construction; forest products, paper, and packaging; industrial manufacturing; metals; and transportation and logistics. In this global Industry 4.0 survey, one-third of the respondents said their company had already achieved advanced levels of integration and digitization, and 72 percent expected to reach that point by 2020 [43].

Due to the ever-changing economic environment, countries around the world have been adjusting development strategies to bring about revitalization for their manufacturing industry. Germany provided the "Industry 4.0" concept; they considered, through leveraging CPS (cyber-physical systems), a smart plant will be established for industrial–academic-research cooperation so as to move towards Industry 4.0. The USA launched the "Advanced Manufacturing Partnership" program, which invested US$2.2 billion for AMP in 2013 to encourage the return of domestic manufacturing and regain its leading position in the manufacturing industry. This trend shifted to Japan and the "Industry Revitalization Plan" has been submitted with the focus on developing robotic technologies to increase production efficiency and added-value, thus reducing manufacturing costs to drive industry transformation. After the 12th Five-Year Plan targeting seven strategic industries, Chinese authorities crafted the "China Manufacturing 2025" white paper to develop smart manufacturing equipment to become a global innovation hub. "Manufacturing Innovation 3.0" is the project the Korean government worked out that aims to realize the implementation of a smart plant by integrating emerging IT, software, and IoT, etc. Taiwan plans to spend NT$45 billion over the next nine years with two phases to help more hidden champions in seven key areas upgrade to "Productivity 4.0" [42,44–46].

2.2.1. Industry 4.0 in China

There are two myths about China's manufacturing; one is that "Made in China" products can be seen everywhere, while the other is that China is becoming a world production center. The fact is, China is currently a "Manu-factory", not a manufacturing powerhouse yet, and the current manufacturing paradigm cannot be sustained, such as labor costs, resource consumption, and environmental damage.

The Chinese government has realized that it needs to upgrade its manufacturing industry and move to higher value-added manufacturing [44].

Most Chinese manufacturers want to move up in the manufacturing value chain in order to be the innovators of high-value added products. However, Chinese manufacturers need, first, to establish their manufacturing core competence and fully understand the know-hows, know-whys, and be able to move beyond copying. Hence, the Chinese government frames their goals for industrial transformation and has made many related policies following this so-called "China Manufacturing 2015" [45].

"China Manufacturing 2025" creates a three-step national strategy for manufacturing industry transforming and upgrading, especially on selected key industries. At the government level, coordinated innovation among industry–academia–institution/government and leveraging the necessary capital market are required to accelerate technology innovation and transformation in order to establish a different development strategy of national innovation. In keeping with the principle of facilitating manufacturing innovation, incubating a manufacturing culture with Chinese features to enhance China's manufacturing context may create an epoch-making manufacturing system. Several concrete contents of "China Manufacturing 2015" include:

1. Innovation driven: focuses on core innovation which can manipulate industry progress to facilitate innovation mechanisms and facilitate interdisciplinary coordinative innovation. Digitization, networking, and intelligentization of the manufacturing industry, with critical technology breakthroughs, may chart a new course of innovation for the Chinese manufacturing sector.
2. Quality improvement: quality control and assurance is the mainstream for establishing a strong manufacturing nation. Quality enhancement is not just on product or service, but enterprise management systems, technology R&D, and branding are all critical issues with respect to quality. Regulations, monitoring, standards systems, and an advanced quality management culture will all be needed to improve the entire market environment, including authentic business operation.
3. Green development: sustainable industry development is the cornerstone of building a strong manufacturing nation. Promotion of energy-saving and environmental protection technologies/skills/equipment will accelerate green tech development and industry upgrading. Developing recycling economics, such as green energy, smartgrid, water-recycling, and especially the recycling efficiency advancement, will enhance the green manufacturing system and lead industry to an eco-friendly development hereafter.
4. Structure optimizing: industrial structure amendment is pivotal for this revolution. More resources will be allocated to manufacturing with advanced technology; the traditional manufacturing sector is set for an industrial upgrade; the manufacturing industry will undergo transformation with models and concepts borrowed from the service sector. From this perspective, industry and enterprise clusters with core competencies and high-quality, and high-effectiveness, will be incubated to fit the structure amendment, which may help map optimal industrial developments and further consolidate future strengths in the manufacturing sector.
5. Talent education: talent pool construction is another crux. Building an integrated and comprehensive education system for enterprises to recruit, employ, foster, and develop long-term competence is necessary. Under this tide of change, talents need not just professional skills, but copious interdisciplinary knowledge, business operation, and co-working ability.

Strategically, the first step of the "China Manufacturing 2025" blueprint is making China into a tier-one manufacturing nation before 2025. The Chinese government plans to spend five years uplifting the digitalization, networking, and smartization competence of manufacturing industry and enhancing horizontal integration. Based on basic manufacturing quality improving, innovation capability and high employee competence would usher in the next stage of development, that is, lower contamination, emissions, and energy wastage on the back of the synergy of industrialization and informatization. Finally, China expects to have leading technology and innovation for those selected industries and frame a prime technology innovation system and the whole industry chain system in 2025, including next-generation information technology, digital-control machine tools and robots, aerospace vehicles and equipment, marine engineering and cutting-edge vessels, new energy vehicles, energy and power equipment, state-of-the-art materials, agricultural equipment, and bio-pharmaceutical and medical equipment sectors, which are the target sectors in the “China Manufacturing 2025” program.

2.2.2. Industry 4.0 in Taiwan

Developed countries around the world currently face challenges of low birth rates and aging populations; Taiwan is no exception. The changing need of consumer IT products, labor shortages, and the manufacturing renaissance in Europe and the USA all put Taiwanese vendors under pressure to transform and upgrade.

Taiwan plans to spend NT$45 billion over the next nine years with two phases to help hidden champions in seven key areas upgrade to “Productivity 4.0”. The Taiwanese government’s plan for developing smart manufacturing via the “three connections”: connecting to the local, connecting to the future, and connecting to the world. “Connecting to the local” means fully utilizing the resources in Taiwan, including the competitive manufacturing industry, and to provide overseas training opportunities for Taiwan’s workers. “Connecting to the future” means adding value to products, especially new technologies. For example, adding GPS and smart location systems on cars. “Connecting to the world” means cooperating with other countries and introducing foreign professionals to Taiwan [46]. The main structure of Taiwan Productivity 4.0 shows in Figure 3 below.

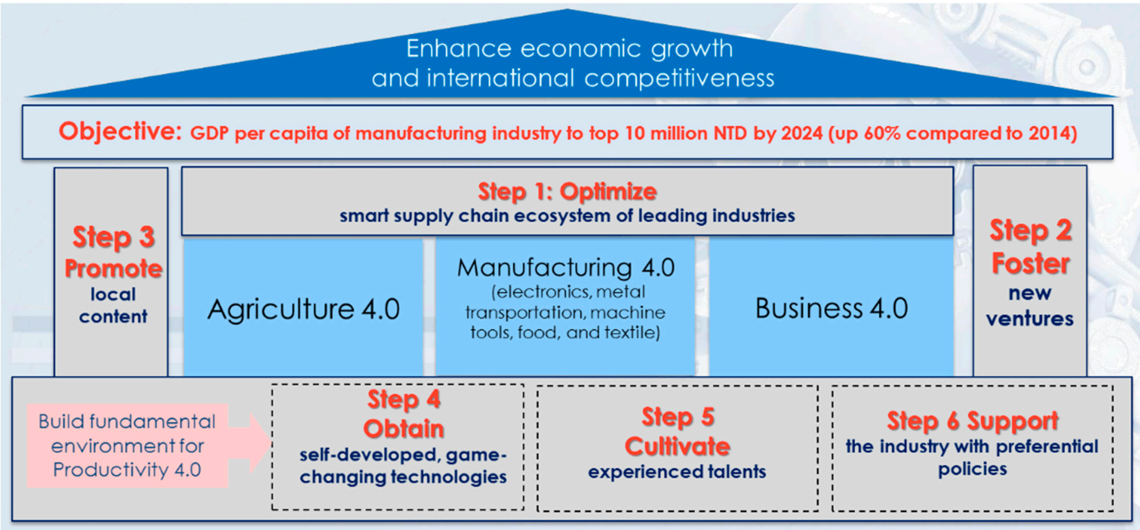

Figure 3. Taiwan Productivity 4.0 framework. Source: Industry Development Bureau, MOEA, 2016, [47].

The objective of Productivity 4.0 is raising GDP per capita of the manufacturing industry to NTD$10 million in 2024, specifically, up 60% compared to 2014. The main strategy will be optimizing the smart supply chain eco-system of the five leading industries, which are electronics and information, metal transportation, machine tools, food, and textile industries. The conceptual framework for Taiwan’s Productivity 4.0 concentrates on leveraging IoT to digitize production of information, extending the use of machines into the Internet of Machines. Further utilizing system management, Big Data, and lean management, the goal is to achieve a novel business model of Internet-based service-manufacturing.

The main directions of Taiwan’s Productivity 4.0 are as follows:

1. International cooperation reinforcement: promoting global heavyweights to team up with leading Taiwanese companies. Bilateral cooperation between flagship companies will encourage Productivity 4.0 and push for an exchange platform to organize Industry 4.0/Productivity 4.0 international forums on a regular basis for cross-regional cooperation and exchanges of experiences.
2. Technological capability enhancement: Introducing Industry 4.0 and experienced experts to help Taiwan's companies, in particular SMEs, adopt Productivity 4.0 and corresponding solutions or platforms for higher productivity. A cooperation of an industrial–academic-research institute will assist in establishing common communication standards in compliance with Productivity 4.0/Industry 4.0.
3. Closer collaboration with strategic partners: Taiwanese companies have their leading position in the global ICT manufacturing industry and are ready to serve as partners of global enterprises in the implementation of Industry 4.0. Closer collaboration with global partners and suitable companies would achieve global market expansion and gain Productivity 4.0 experience.

There are six steps in building the Taiwan Productivity 4.0 plan. First, optimizing the smart supply chain ecosystem, especially in critical leading industries. Second, fostering new ventures; the movement of new ventures and startups is strong and prosperous in Taiwan. However, incubating and accelerating the new ventures in CPS-related areas, solution services, materials, medical, and smart manufacturing could facilitate sustainable competence-building. Third, promoting those local contents with competitiveness—such as critical components, systems, or services—will help enhance their capabilities of Productivity 4.0. The forth step will be obtaining self-development and game-changing technology capabilities. Cultivating experiences and talents through industrial–academic-institute cooperation, interdisciplinary learning, and international linking to build up their own competitiveness will be the fifth step. The last step is to support industry development and lead enterprise proliferation by the necessary industry policy tools to complete the whole ecosystem.

3. Methodology and Data Survey

Data Survey and Pattern Matching

In this research, innovation policies regarding Industry 4.0 in China and Taiwan are investigated using content analysis. This section explains the collection of policy data in China and Taiwan and the pattern matching approach used. First, the data sourced and analyzed in this research were collected from government reports, journal papers, historical documents, newspaper stories, open-ended interviews, diplomatic messages, and official publications. Three issues that enabled us to produce a full comparison are discussed: (1) we survey the policy landscape and list a range of policies within China and Taiwan; (2) we introduce the character and tendency of each nation's Industry 4.0 policy and converted them into Tables 1 and 2 and (3) we rank the priorities for each nation's Industry 4.0 innovation policy. This is followed by a comparison of each nation's Industry 4.0 policy that highlights differences in each country.

The cross-national analysis of Industry 4.0 mainly depends on qualitative content analysis and descriptive statistics. Content analysis is, therefore, one of the main methods used to systematically gain an in-depth picture of policy tools. Such datasets may not be statistically representative, but they provide a rich understanding of the innovation policy that can be employed for the development of Industry 4.0 policy. Descriptive statistics are used to quantitatively explain the main features of a set of Industry 4.0 policies. This study also uses a pattern-matching approach to fit the Industry 4.0 policies we collected from China and Taiwan into the innovation policy framework of Rothwell and Zegveld. Table 3 describes how the policy tools from each survey case or source match or do not match the innovation policy pattern using Yin's (1989) pattern-matching structure [48].

Table 1. Policy tools classification in China.

Dimension	Policy Tools	Policy Statements and Description	Total No.	%
Supple Side Policy (9)	Public enterprise		0	0%
	Scientific and technical	To enhance national manufacturing innovation capability (1); enhance basic industry ability (1)	2	2%
	Education	To complete multi-level talent education system (6)	6	5%
	Information	To complete multi-level talent education system (1)	1	1%
Environmental-side Policy (73)	Financial		0	
	Taxation		0	
	Legal and regulatory	To enhance national manufacturing innovation capability (2); enhance brand quality construction (4); promote thorough restructuring of the manufacturing sector (1); deepen transformation mechanism (2); create a fair competition environment (8); complete multi-level talent education system (1); render manufacturing more open to foreigners (2)	20	19%
	Political	To enhance national manufacturing innovation capability (1); infuse informatization and industrialization (4); enhance basic industry ability (2); enhance brand quality construction (2); Green manufacturing (1); highlight area breakthrough (10); promote thorough restructuring of the manufacturing sector (3); develop servicing manufacturing and producer service (1); raise international level (3); deepen transformation mechanism (4); complete financial supporting policy (6); increase fiscal policy support (4); complete multi-level talent education system (1); render manufacturing more open to foreigners (1); complete organization execution mechanism (10)	53	49%
Demand-side Policy (25)	Procurement	To increase fiscal policy support (1)	1	1%
	Public services	To: enhance national manufacturing innovation capability (1); infuse informatization and industrialization (1); develop servicing manufacturing and producer service (2); deepen transformation mechanism (2); complete financial supporting policy (3); increase fiscal policy support (2); complete multi-level talent education system (1); complete SMEs policy (7); render manufacturing more open to foreigners (1)	20	19%
	Commercial	To enhance national manufacturing innovation capability (1); enhance brand quality construction (1)	2	2%
	Overseas agent	To render manufacturing more open to foreigners (2)	2	2%
Total			107	100%

Table 2. Policy tools classification in Taiwan.

Dimension	Policy Tools	Policy Statements and Description	Total No.	%
Supple Side Policy (20)	Public enterprise		0	0%
	Scientific and technical	To control core tech self-development ability (2)	2	2%
	Education	Industry in-service talent education (6); industry–academia linkage and interdisciplinary talent education (6); encourage international practical talent (3); foster industry practical talent (3)	18	17%
	Information		0	0%
Environmental-side Policy	Financial	New venture incubation and technology localization-manufacturing (1)	1	1%
	Taxation	Industry transformation and upgrade policy (1)	1	1%
	Legal and regulatory	Int'l ICT linkage hub and standard making (3); build product, technology, process verification system (4); industry transformation and upgrade policy (1)	8	8%
	Political	To enhance vertical enterprise value chain smartization capability (3); industry horizontal value chain smartization capability (3); build industry counselling system (3); spin-off new venture policy (1); introduce int'l related enterprise for local emerging industry (1); enhance key component and system self-development capability (3); introduce int'l product or service for building self-development capability (1); control CPS core tech self-development ability (1); introduce manufacturing transformation system framework (3); industry transformation scenario establishing-manufacturing (5); industry counselling group (2); industry transformation scenario establishing-servicing (4); new venture incubation and technology localization-servicing (1); agriculture transforming framework (1); industry transforming scenario establishing-agriculture (10); develop critical core technology (3)	45	44%

Table 2. *Cont.*

Dimension	Policy Tools	Policy Statements and Description	Total No.	%
Demand-side Policy	Procurement		0	0%
	Public services	To assist local company links into the global supply chain (2); spin-off new venture policy (2); introduce int'l-related enterprise for local emerging industry (2); introduce int'l product or service for building self-development capability (1); control CPS core tech self-development ability (3); industrial–academic-institute collaboration on recruiting int'l experts (3); industry transformation and upgrade policy (3); new venture incubation and technology localization-manufacturing (2); servicing industry transformation framework (4); new venture incubation and technology localization-servicing (2); agriculture transformation framework (2)	26	25%
	Commercial	Spin-off new venture policy (1)	1	1%
	Overseas agent	To assist local company links with the global supply chain (1)	1	1%
Total			103	100%

Table 3. Government policy instruments for industrial innovation.

Dimension	Policy Tools	Remarks
Supple Side Policy	Public enterprise	Innovation by state-owned enterprises and institutions; focusing on developing new industries; pioneering in the use of new technology; joint developments with private enterprises.
	Scientific and technical	Engaged in scientific and technical research; support for research institutes; developing learning society, professional organizations; offering research grants in support of industrial innovation.
	Education	Government support for education and training at all levels, including general education, higher education at university, and post-graduate levels, vocational education, apprenticeship programs, and continual education.
	Information	Government support in developing information networks of business intelligence for private enterprises, business centers, libraries, advisory, and consultancy services, cloud databases, and liaison services.
Environmental-side Policy	Financial	Government support and subsidy for industrial innovation for specific projects, joint financial investments, provision of equipment loans, arranging third-party financing, loan guarantees and IPO assistance, and export credits.
	Taxation	Tax exemption and reductions for industrial innovation for specific projects, R&D tax credits, capital gain tax exemption, personal tax allowances.
	Legal and regulatory	Patents and intellectual property management, regulatory agendas for environmental and health control, accreditation and certification management, anti-trust regulations and social justice supervision, awards and prizes, and protocol standards.
	Political	Strategic planning of national innovation programs, regional development policies, awards and prizes for innovation, support of mergers and acquisitions, and think-tank and public consulting for policy exploitation, and political and legal systems for investment.
Demand-side Policy	Procurement	Central or local government purchases and contracts, R&D contracts, and technology transactions via government procurement.
	Public services	Infrastructural and institutional developments in science park development, facilitating market transactions, banking service, maintenance and management of innovation diversity and applications, provision of health insurance and services, transportation and telecommunication, social transformation.
	Commercial	Trade agreements, tariffs, currency regulations, commercialization, and industrialization of innovation.
	Overseas agent	Overseas representation for international trade and transactions, developing official organizations in support of internationalization of innovation.

For data collection, researchers can use documents, newspapers, interviews, direct observations, participating observations, and reality descriptions as case studies [49]. In addition, in this pattern-matching of policy tools for cross-national comparison, all policy tools are given equal weight even though they are not all likely to have an equal impact on Industry 4.0 development in China and Taiwan. This assumption was used to develop this cross-national policy analysis and should be considered a limitation of the research. The assumption regarding all policies having an equal weighting impact was introduced at this stage for two reasons: (1) little research exists in the area of cross-national policy in Industry 4.0. As a starting point in this emergent energy sector, it may be risky to assume different weights for each policy tool based upon our observations of other industry or energy sectors. This weighting may also result in further bias in possible future studies; and (2) The weighting will probably differ depending on the country context because the resource restrictions and policy infrastructures are different in China and Taiwan. Assuming that all policies deserve an equal weighting, impact appears to be the most appropriate research strategy at this initial research stage.

4. Results

Based on government official reports, including "China Manufacturing 2025", "Taiwan Productivity 4.0 Initiative", and other related white papers that ensued, this research collected 107 policy tools applied by Chinese authorities and 103 policy tools requested by Taiwan. Table 1 shows the policy tools used in China Industry 4.0 development. Table 2 shows the policy tools usage classification of Taiwan.

The classification of collected policy tools of China and Taiwan renders a comparison Table 4 to distinguish the difference between China and Taiwan.

Table 4. Comparison of China and Taiwan policy tools.

Dimension	Policy Tools	China		Taiwan	
		Amount	%	Amount	%
Supple Side Policy	Public enterprise	0	0	0	0
	Scientific and technical	2	2	2	2
	Education	6	5	18	17
	Information	1	1	0	0
	Sum	9	8	20	19
Environmental-side Policy	Financial	0	0	1	1
	Taxation	0	0	1	1
	Legal and regulatory	20	19	8	8
	Political	53	49	45	44
	Sum	73	68	55	54
Demand-side Policy	Procurement	1	1	0	0
	Public services	20	19	26	25
	Commercial	2	2	1	1
	Overseas agent	2	2	1	1
	Sum	25	24	28	27
Total		107	100	103	100

In the "China Manufacturing 2025" plan, Chinese authorities allocate 8% weighting to 'supply-side policy', with most resources distributed to 'environmental-side policy', with 68% and then 24% to 'demand-side policy'. In all policy tools, 'political tools' is prioritized with 49% weight, while 'legal and regulatory' and 'public services' both receive 19%. Thus, 'political tools' and 'legal and regulatory' both belong to environmental-side policy and make this dimension the most important one. Table 5 shows the comparison of weight and priority of policy tools between China and Taiwan.

On the other hand, the Taiwanese government enacts the "Productivity 4.0 plan", which distributes most resources to 'environmental-side policy' with 54% weighting; 27% weight went to 'demand-side policy', with 'supply-side policy' at 19%. 'Political tools' tops all policy tools with 44% weight, followed by 'public service' with 25%, while 'education' comes in third with 17%. In terms of the overall allocation of resources, the rest of the policy tools account for a smaller percentage. Figures 4 and 5 show the scattering diagram of the 12 policy tools.

Table 5. Weight priority of cross-strait policy tools.

China			Taiwan		
Priority	**Policy Tool**	**Weight**	**Priority**	**Policy Tool**	**Weight**
1	Political	49%	1	Political	44%
2	Legal and regulatory	19%	2	Public services	25%
2	Public services	19%	3	Education	17%
4	Education	5%	4	Legal and regulatory	8%
5	Scientific and technical	2%	5	Scientific and technical	2%
5	Commercial	2%	6	Financial	1%
5	Overseas agent	2%	6	Taxation	1%
8	Information	1%	6	Commercial	1%
8	Procurement	1%	6	Overseas agent	1%
10	Public enterprise	0%	10	Public enterprise	0%
10	Financial	0%	10	Information	0%
10	Taxation	0%	10	Procurement	0%

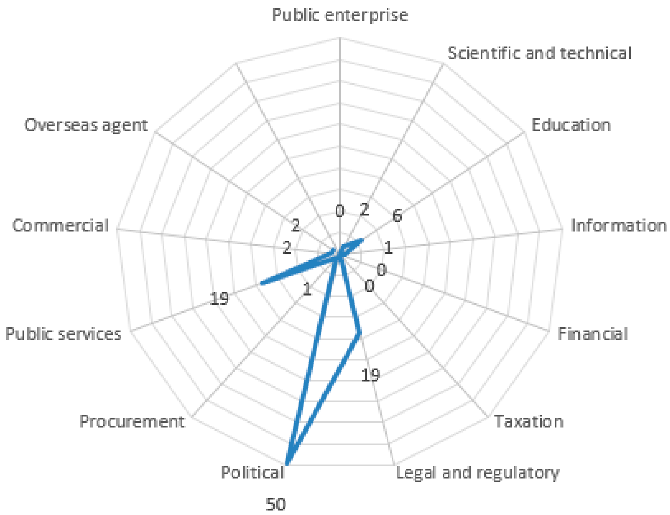

Figure 4. China Manufacturing 2025 policy tools scattering diagram.

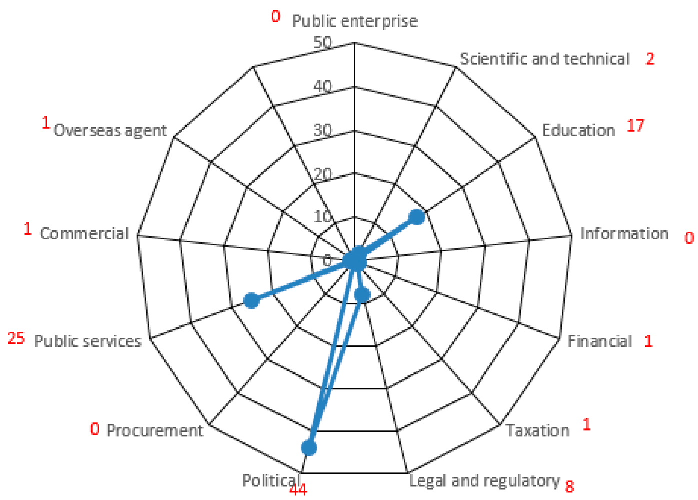

Figure 5. Taiwan Productivity 4.0 policy tools scattering diagram.

5. Conclusions and Implications

5.1. Analysis of Results

This research used two official white papers, "China Manufacturing 2025" and "Taiwan Productivity 4.0", as the foundation and adopted 12 policy tools to classify the policy tools usage between China and Taiwan. The findings and results of pattern-matching are summarized below:

1. Policy dimension comparison: Taiwan and China both focus on three policy dimensions, among which 'environmental-side' draws the most attention, followed by 'demand-side' policy, with the 'supply side' considered to be of lesser importance. Although the weightings are not identical, both sides of the Taiwan Strait concentrate on the same policy dimensions. Both China and Taiwan tend to focus more on environmental-side policies because industrial competition advantages may be enhanced through upgrading the industrial environment. These policy tools will be helpful toward developing industry innovation and the domestic market environment by allocating financial resources and developing political support to the industrial structure.
2. Policy tools level:
   (1) 'Political tools' holds a special position for both governments: China and Taiwan governments seem to have similar preferences for political tool usage. Political tools hold the number one position both in China and Taiwan. We refer back to the definition proposed by Rothwell and Zegveld (1981) and their causal process of policy tools presented in Figure 1. These political tools will improve the R&D activities and indirectly support industry development and innovation. With respect to Industry 4.0, this means that China and Taiwan's governments tend to adopt this policy tool first when cultivating industry innovation and accelerating emerging technologies, talents, and mechanism infusion [8].
   (2) Over 90% of resources go to the top four policy tools: Although the priority is not exactly the same, the top four policy tools for both governments are the same, which are 'political tools', 'public service', 'legal and regulatory', and 'education'. China allocates 92% and Taiwan distributes 94% to these critical tools. Resource allocation is similar for China and Taiwan.
   (3) 'Public enterprise' is not emphasized: According to the research results, the two governments focus less on public enterprise. This result is not new for Taiwan industrial development, but novel for China. Facing myriad challenges, the tide of the new 'retreat of the state, advance of the private sector' may be formulating.
   (4) Several differences after analysis: The Chinese authority stresses less on 'financial' and 'taxation' tools; conversely, the Taiwan government concentrates less on 'information' and 'procurement' tools.
3. Analysis of policy implications:
   (1) China Manufacturing 2025: Strategically, the Chinese government puts more emphasis on critical industrial and technological breakthroughs, organization implementation mechanism amendment, and the establishment of complete financial supporting systems. The execution of policy tools matches the innovation-driven structure optimization and quality-improving key points within the overall "China Manufacturing 2025" program.
   (2) Taiwan Productivity 4.0: Relatively, the Taiwanese government concentrates more on industry transformation and scenario establishment—be it manufacturing, service, or agriculture sectors. Integration of the industrial–academic-institute system is another emphasis which covers education, new venture spin-offs, and international cooperation.
   (3) In China, establishing a fair competition market to facilitate industry development is the core of the 'legal and regulatory' section. The 'public service' part emphasizes assisting SME development.

(4) 'Public service' in Taiwan puts more focus on building systematic structures, and scenarios for industry transformation, manufacturing, service, and agriculture industries are all included.

Different social-political, cultural, economic, or technical contexts will influence the policy tools and the execution in varied ways [49]. The resources differ from China to Taiwan, but the main policy tools between the two governments are similar, which may be result in different industry features in the future.

5.2. Discussion and Conclusions

This study reveals the different strategies when applying innovation policy for developing Industry 4.0 across the Taiwan Strait. For both governments of China and Taiwan, the policy focus has been placed on environmental-side policy such that needed infrastructure by Industry 4.0 may be developed. On the contrary, China tends to focus on 'environmental-side' and 'demand-side' policy, but Taiwan favors distributing resources into all three policy categories. While China has targeted 10 specific industries for preferential development in its national program of "Made-in-China 2025", Taiwan's policy orientation has been placed only on 'manufacturing' without any specificity of industry type.

Based on the cross-comparison of specific policy details, "China Manufacturing 2025" and "Taiwan Productivity 4.0", China and Taiwan both concentrate on environmental-side tools of public services tool; however, China focuses more on 'legal and regulatory' for comprehensive quality improvement and Taiwan prefers 'education' for complete talent cultivation promotion. In China, policies are getting increasingly sustainable, and they aim at long-term development (five years at least). The authority in China focuses on environmental-side policy, especially on 'legal and regulatory', to pursue an intact mechanism for manufacturing upgrade and self-innovation enhancement. For industry level, Taiwan concentrates on the upgrading of existing industries, such as agriculture, IT, and medical devices; in contrast, China selects 10 major industries for global competition.

Policy-making and planning is a long-term prospect in China, "China Manufacturing 2025" is no exception, as this plan targets on overall enforcement of the Chinese manufacturing industry to secure a globally advantageous position. China owns widespread territory and myriad domestic market which could provide sufficient nutrition for industry growing. Tactically, through environmental-side policy tools and public service usage, Chinese authority expects more advanced innovation from the technology side, business models to procedures, to leap ahead on cutting-edge equipment, material, and integrated emerging industries. The global industrial structure and competition situation of Industry 4.0 is still chaotic, and there are many uncertainties in industry-shaping, thus, the use of 'political' and 'legal and regulatory' policy tools to facilitate industry and main enterprises growing with efficiency and effectiveness is reasonable.

The "Productivity 4.0" program proposed by the Taiwanese government tries to infuse Industry 4.0 concepts and plans into the existing industrial structure, so that industry selection and focus are not ignored when executing the plan, for example, with respect to medical equipment, agriculture, and so on. Compared to China, this revitalization plan is a relatively short-term, scale-limited action plan which relatively balances three policy dimension and focuses more on efficiency tactics. In Taiwan, the authority expects to incubate SMEs and startups which are involved in fields of Industry 4.0 to balance the possible market blank under this transition. Enhancement of existing competitive industries and cultivation of potential creative new ventures broadly reflect the policy implications in Taiwan. As Taiwan is relatively insufficient for resources, and thus 'education' and 'public service'—including linkage to global supply chain, international experts recruiting, and new venture incubation—show an important role in this industry transition. Interestingly, the execution plan of 'public services' tools, both in China and Taiwan, implies an open innovation prospect [50]. The boundary of firms gets blur and innovations are floating between industrial–academic-institute which make collaboration and incubation more important.

Market size, industrial competition situation, national resource limitation, and government operation system may all be reasons causing this policy allocation difference. The results and conclusion show a match type accompanied with the co-opetition between China and Taiwan now and in the coming future.

This research provides a theoretical analysis of innovation policy, but adopts a rather pragmatic approach. It describes, in detail, a number of innovation policies currently being pursued under Industry 4.0 and contributes to Industry 4.0 policy research by applying the innovation policy framework to explore policy dynamics in China and Taiwan. Based on this finding, policy-makers can enhance the implementation, outcomes, and quality of their initiatives. Planning based on innovation policy should consider the temporal dynamics of such policies and attempt to mitigate disadvantages at each stage. By integrating this perspective into policy planning, both the necessary resources and the potential outcomes can be optimized.

This study analyzes innovation policy on Industry 4.0, and the contribution here offers a cross-strait comparison and a static analysis for policy-makers. There are still limitations—such as the implementation of policy, the interaction between policy tools, and so on—which could prompt future research. Due to this limitation, the findings of this study may not be easily generalized to all Industry 4.0 sectors and may be subject to other interpretations [51]. Industry transformation and paradigm shift may lead to a necessary business model change [52]. This study aims at the national and industrial levels of Industry 4.0 but doesn't get down into firm level which will be a limitation. These limitations will raise new starting points for the future study of Industry 4.0.

Author Contributions: Shyu is the main person adopted Rothwell and Zegveld's policy model and overall planning this research especially the implications and conclusion. Lin takes charge of literature review, data aggregation, research findings and conclusions. Ding focus in related China policy collection, deduction and consolidation.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Gilchrist, A. *Industry 4.0—The Industrial Internet of Things*; Springer Science+Business: New York, NY, USA, 2016.
2. Brettel, M.; Friederichsen, N.; Keller, M.; Rosenberg, M. How Virtualization, Decentralization and Network Building Change the Manufacturing Landscape: An Industry 4.0 Perspective. *Int. J. Mech. Aerosp. Ind. Mechatron. Manuf. Eng.* **2014**, *8*, 37–44.
3. Schlechtendahl, J.; Keinert, M.; Kretschmer, F.; Lechler, A.; Verl, A. Making existing production systems Industry 4.0-ready. *Prod. Eng. Res. Dev.* **2015**, *9*, 143–148. [CrossRef]
4. Kagermann, H. Change through Digitization-Value Creation in the Age of Industry 4.0. In *Management of Permanent Change*; Albach, H., Meffert, H., Pinkwart, A., Reichwald, R., Eds.; Springer: Wiesbaden, Germany, 2015; pp. 23–45.
5. Wang, S.; Wan, J.; Li, D.; Zhang, C. Implementing Smart Factory of Industrie 4.0: An Outlook. *Int. J. Distrib. Sens. Netw.* **2016**, *2016*, 1–10. [CrossRef]
6. Thoben, K.-D.; Wiesner, S.; Wuest, T. "Industrie 4.0" and Smart Manufacturing—A Review of Research Issues and Application Examples. *Int. J. Automot. Technol.* **2016**, *11*, 4–16.
7. Kang, H.S.; Lee, J.Y.; Choi, S.S.; Kim, H.; Park, J.H.; Son, J.Y.; Kim, B.H.; Noh, S.D. Smart Manufacturing: Past Research, Present Findings, and Future Directions. *Int. J. Precis. Eng. Manuf. Green Technol.* **2016**, *3*, 111–128. [CrossRef]
8. Schuh, G.; Potente, T.; Wesch-Potente, C.; Weber, A.R.; Prote, J.-P. Collaboration Mechanisms to increase Productivity in the Context of Industrie 4.0. *Procedia CIRP* **2014**, *19*, 51–56. [CrossRef]
9. Pfeiffer, S. The Vision of Industrie 4.0 in the Making—A Case of Future Told, Tamed, and Traded. *NanoEthics* **2017**, *11*, 107–121. [CrossRef] [PubMed]

10. Dodgsona, M.; Hughesb, A.; Fosterc, J.; Metcalfe, S. Systems thinking, market failure, and the development of innovation policy: The case of Australia. *Res. Policy* **2011**, *40*, 1145–1156. [CrossRef]
11. Schumpeter, J. *The Theory of Economic Development*; Harvard University Press: Cambridge, MA, USA, 1934.
12. Afuah, A. *Innovation Management: Strategies, Implementation, and Profits*; Oxford University Press: New York, NY, USA, 1998.
13. Edquist, C.; Hommen, L. Systems of innovation: Theory and policy for demand-side. *Technol. Soc.* **1999**, *21*, 63–79. [CrossRef]
14. Shyu, J.Z.; Chiu, Y.C. Innovation policy for developing Taiwan's competitive advantages. *R&D Manag.* **2002**, *32*, 369–374.
15. Kirschen, E.S. *Economic Policy in Our Time*; North-Holland Publishing Company: Amsterdam, The Netherlands, 1964; pp. 222–225.
16. Schneider, A.; Ingram, H. Behavioral Assumptions of Policy Tools. *J. Politics* **1990**, *52*, 510–529. [CrossRef]
17. Burns, J.D.; Kang, J.S. Comparative economic analysis of supporting policies for residential solar PV in the United States: Solar Renewable Energy Credit (SREC) potential. *Energy Policy* **2012**, *44*, 217–225. [CrossRef]
18. Sanya, C. State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy* **2009**, *37*, 3071–3081.
19. Yılmaz, A.O.; Uslu, T. Energy policies of Turkey during the period 1923–2003. *Energy Policy* **2007**, *35*, 258–264. [CrossRef]
20. Lau, L.C.; Tan, K.T.; Lee, K.T.; Mohamed, A.R. A comparative study on the energy policies in Japan and Malaysia in fulfilling their nations' obligations towards the Kyoto Protocol. *Energy Policy* **2009**, *37*, 4771–4778. [CrossRef]
21. Laird, F.N.; Stefes, C. The diverging paths of German and United States policies for renewable energy: Sources of difference. *Energy Policy* **2009**, *37*, 2619–2629. [CrossRef]
22. Kim, T.Y.; Kim, S.R. An integrated energy policy for Korea: The case of an energy importing country. *Energy Policy* **1993**, *21*, 1001–1010. [CrossRef]
23. Kissel, J.M.; Krauter, S.C.W. Adaptations of renewable energy policies to unstable macroeconomic situations—Case study: Wind power in Brazil. *Energy Policy* **2006**, *34*, 3591–3598. [CrossRef]
24. Negro, S.O.; Hekkert, M.P. Explaining the success of emerging technologies by innovation system functioning: The case of biomass digestion in Germany. *J. Technol. Anal. Strateg. Manag.* **2008**, *20*, 456–482. [CrossRef]
25. Rothwell, R.; Zegveld, W. *Industrial Innovation and Public Policy*; Praeger: Santa Barbara, CA, USA, 1981.
26. Rothwell, R.; Zegveld, W. An assessment of government innovation policies. *Rev. Policy Res.* **1984**, *3*, 436–444. [CrossRef]
27. Rothwell, R.; Zegveld, W. An assessment of government innovation policy. In *Government Innovation Policy: Design, Implementation, Evaluation*; Roessner, D., Ed.; Macmillan Press: London, UK, 1988; pp. 19–36.
28. Norberg-Bohm, V. Stimulating "green" technological innovation: An analysis of alternative policy mechanisms. *Policy Sci.* **1999**, *32*, 13–38. [CrossRef]
29. Norberg-Bohm, V. Creating incentives for environmentally enhancing technological change: Lessons from 30 years of U.S. Energy Technology Policy. *Technol. Forecast. Soc. Chang.* **2000**, *65*, 125–148. [CrossRef]
30. Loiter, J.M.; Norberg-Bohm, V. Technology policy and renewable energy: Public roles in the development of new energy technologies. *Energy Policy* **1999**, *27*, 85–97. [CrossRef]
31. Lai, H.C.; Chang, S.C.; Shyu, J.Z. The innovation policy priorities in industry evolution: The case of Taiwan's semiconductor industry. *Int. J. Foresight Innov. Policy* **2004**, *1*, 106–125. [CrossRef]
32. Tuan, C.; Ng, L. Evolution of Hong Kong's electronics industry under a passive industrial policy. *Manag. Decis. Econ.* **2007**, *16*, 509–523. [CrossRef]
33. Lin, C.C.; Yang, C.H.; Shyu, J.Z. A comparison of innovation policy in the smart grid industry across the pacific: China and the USA. *Energy Policy* **2013**, *57*, 119–132. [CrossRef]
34. Forbes Magazine. What Everyone Must Know about Industry 4.0. Available online: https://www.forbes.com/sites/bernardmarr/2016/06/20/what-everyone-must-know-about-industry-4-0/#33c265bb795f (accessed on 5 May 2017).
35. United Nations Industrial Development Organization. Emerging Trends in Global Manufacturing Industries. Available online: https://www.unido.org/fileadmin/user_media/Services/PSD/Emerging_Trends_UNIDO_2013.PDF (accessed on 5 May 2017).

36. Marr, B. *Data Strategy—How to Profit from a World of Big Data, Analytics and the Internet of Things*; Kogan Page Ltd.: London, UK, 2017.
37. Deloitte. Industry 4.0: Challenges and Solutions for the Digital Transformation and Use of Exponential Technology. Available online: https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf (accessed on 5 May 2017).
38. Germany Trade and Invest (GATI). Industry 4.0—Smart Manufacturing for the Future. Available online: https://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Brochures/Industries/industrie4.0-smart-manufacturing-for-the-future-en.pdf (accessed on 5 May 2017).
39. De Mauro, A.; Greco, M.; Grimaldi, M. A formal definition of Big Data based on its essential features. *Libr. Rev.* **2016**, *65*, 122–135. [CrossRef]
40. Pedro, L.M.; Mafalda, P.R.; Andre, D.R.; Jose, B.O. Big Data Analysis to Ease Interconnectivity in Industry 4.0—A Smart Factory Perspective. In Proceedings of the SOHOMA 2016, Monte de Caparica, Portugal, 6–7 October 2016; Theodor, B., Damien, T., André, T., Paulo, L., Barata, O.J., Eds.; SpringerLink: New York, NY, USA, 2016.
41. Thames, L.; Schaefer, D. Industry 4.0: An Overview of Key Benefits, Technologies, and Challenges. In *Cybersecurity for Industry 4.0*; Thames, L., Schaefer, D., Eds.; SpringerLink: New York, NY, USA, 2017.
42. Moavenzadeh, J. The 4th Industrial Revolution: Reshaping the Future of Production. In Presented at DHL Global Engineering & Manufacturing Summit, Amsterdam, The Netherlands, 6–8 October 2015.
43. PricewaterhouseCoopers International Limited (PwC). Industry 4.0: Building the Digital Enterprise. Available online: https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf (accessed on 5 May 2017).
44. Boston Consulting Group. The Shifting Economics of Global Manufacturing. Available online: http://www.relooney.com/NS3040/000_New_1842.pdf (accessed on 5 May 2017).
45. The State Council of People's Republic of China. *China Manufacturing 2025 White Paper*; The State Council of People's Republic of China: Beijing, China, 2015.
46. Ministry of Economic Affairs, R.O.C. *Taiwan Productivity 4.0 Initiative*; Ministry of Economic Affairs, R.O.C.: Taipei, Taiwan, 2015.
47. Industry Development Bureau, Ministry of Economic Affairs, R.O.C. Smart Machine and Productivity 4.0 in Taiwan: Now and Future. In Proceedings of the Taiwan-Germany Productivity/Industry 4.0 Forum, Taipei, Taiwan, 30 May 2016.
48. Yin, R.K. *Case Study Research: Design and Methods*; Sage: Thousand Oaks, CA, USA, 1989.
49. McNeely, C.L.; Hahm, J. The Big (Data) Bang: Policy, Prospects, and Challenges. *Rev. Policy Res.* **2014**, *31*, 304–310. [CrossRef]
50. Chesbrough, H.W. The Era of Open Innovation. *MIT Sloan Manag. Rev.* **2003**, *44*, 35–41.
51. Creswell, J.W. *Research Design, Qualitative, Quantitative, and Mixed Methods Approaches*, 2nd ed.; Sage Publisher: Thousand Oaks, CA, USA, 2003.
52. Tapscott, D.; Williams, A. *Wikinomics: How Mass Collaboration Change Everything*; Expanded Edition; Portfolio: London, UK, 2010.