


The resurgence of industrial policies in the age of advanced manufacturing: an international comparison of industrial policy documents*

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ABSTRACT

This paper analyses recent industrial policy plans made by five leading countries: China, Germany, Japan, United Kingdom and United States. This is done through the analysis of policy documents, using an original framework. Our analysis reveals that these policies have two main motivations. First, the acknowledgement of new technological opportunities

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and challenges, that allow not only for higher growth rates and competitiveness, but also for addressing ‘societal challenges’ (persistent socio-environmental problems). Second, the growing understanding that, because of the increasing complexity of innovation, private sector efforts alone are not enough, and a higher level of convergence between actors and institutions is needed. We also identify that the policy structures and proposed instruments of these strategies are quite conventional, which contrasts with the rhetoric of these policies. This reveals that the ‘resurgence’ of industrial policies is yet not a return to the ‘old’ policies of the twentieth century, but a new breed, which is much more cautious of interfering with market mechanisms.

KEYWORDS | Industrial policy; Innovation strategies; Policy framework; Advanced manufacturing; Fourth Industrial Revolution

1. Introduction

The global crisis of 2008 has led to a resurgence in the interest and use of industrial policies in various countries. More recently, this trend has gained momentum with the acknowledgement of a wave of technological innovations, known as the ‘Fourth Industrial Revolution’ (SCHWAB, 2017), ‘Industry 4.0’ (ACATECH, 2013), ‘Digital Transformation’ (FÆSTE; SCHERER; GUMSHEIMER, 2015; MCKINSEY, 2018), or ‘Advanced Manufacturing’ (EOP, 2012a; 2014; 2016). Despite the variety of denominations, these are all innovations that are characterised by the abundant use of data, and the convergence or ‘fusion’ of technologies from different fields of knowledge (OECD, 2017). In essence, the new trend of industrial policies targets the development of innovative activities (CASTRO, 2009; MELO; FUCIDJI; POSSAS, 2015).

This paper analyses recent industrial policy plans made by five leading countries in the field of science and technology: China, Germany, Japan, United Kingdom (UK), and the United States (US). This is done through the analysis of key policy documents, using an original framework that accounts for the dynamics and the complexities of the policy process, including the rhetoric (or ‘narrative’) that supports each plan. Thus, this paper aims to answer the following questions:

- *What are the justifications presented by governments for the need for national strategies?*
- *What is new in these strategies in terms of industrial and innovation policy structure and instruments?*
- *What are the similarities and differences in approaches of different countries to the emergence of this new wave of technological innovations?*

Besides this introduction and the conclusion, the paper is divided in four sections. The next section discusses the resurgence of industrial policy in the context of advanced manufacturing. Section three presents the methodology and framework used to analyse the selected policy plans, while section four examines the industrial policy strategies of the five selected countries, and section five compares them through cross-case analysis.

2. The resurgence of industrial policies

In the first three quarters of the twentieth century, interventionist policies were widely used both in advanced and less-developed economies. From the 1970-80s on, with the rise of neoliberal ideas and practices, active industrial policies lost space, with theories on government failures and rent seeking predominating in the academic debate (KUEGER, 1974, 1990; see also TULLOCK; SELDON; BRADY, 2002). In many cases, government action limited itself to determining the ‘rules of the game,’ ‘levelling the playing field,’ and promoting liberalization and privatization policies. These would prioritize non-selective (horizontal) industrial policies, frequently under other names, such as ‘competitiveness policies’ or ‘productivity policies’¹ (NAUDÉ, 2010).

In the 1990s, a better theorization of the process of learning in firms, especially those made by evolutionary economists, led to a change in the focus of the debate to a vision based on ‘systems of learning and innovation’ (FREEMAN, 1988; NELSON, 1988; LUNDVALL, 1988), with an emphasis on human and social capital, institutions, research capacity, technological and innovative performance of firms, and in absorptive capacity (COHEN; LEVINTHAL, 1990). This period also saw the transformation of industrial policies into innovation policies (SOETE, 2007; CASTRO, 2009).

Recently, however, the debate on industrial policy has returned to the academic and policy spotlight (RODRIK, 2004, 2013; STIGLITZ; LIN; PATEL, 2013; CHERIF; HASANOV, 2019). In academia, this reappraisal of industrial policy seemed to be driven by: (1) The failure of Washington Consensus policies in promoting development and increasing the well-being of less-developed countries; (2) The 2008 global financial crisis, which created a context of distrust in the market as an efficient allocator of resources; (3) The economic success of China – an avid user of industrial policies (NAUDÉ, 2010); and (4) Growing evidence of the fundamental role of the state in the successful cases of economic development not only in the nineteenth and eighteenth centuries (CHANG, 2002; REINERT, 2007) but also in the twentieth century – e.g. Japan (JOHNSON, 1982; NESTER, 1991), the East Asian ‘Tigers’ (AMSDEN, 1992; CHANG, 1993; KIM, 1997), and the US (BLOCK, 2008; MAZZUCATO, 2013).

1 The very definition of ‘industrial policy’ is object of debate – some authors argue that it is necessarily selective, others that any policy that affects the allocation of resources in an economy is an industrial policy. We do not wish to enter this discussion, but will highlight that by industrial policies we refer to the policies that seek to directly affect any productive sectors in an economy, i.e. not only manufacturing, but also agriculture and services.

Out of these debates on industrial policy is emerging a fragile consensus. Specifically, the question is not whether industrial policies should be used, but rather *how* to do so effectively. In this regard, at least three (non-exhaustive) lines of thinking can be identified on how industrial policies should be conducted (cf. CASTRO, 2009). First, authors endorsing a ‘market failure’ approach emphasize that industrial policies should focus on sectors with higher knowledge and learning spillover effects, thus correcting market failures related to knowledge (RODRIK, 2004, 2013; STIGLITZ; GREENWALD, 2015; AGHION; BOULANGER; COHEN, 2011). Second, based on the idea of a ‘developmental’ or an ‘Entrepreneurial State,’ some authors also emphasise knowledge and learning, but give the state a role not only in correcting market failures, but also in shaping and creating new markets. The priority of the state should be in establishing networks of private sector agents and channelling resources of the economy for the most uncertain stages of the innovation process, in order to resolve grand challenges and achieve technological missions (BLOCK; KELLER, 2011; MAZZUCATO, 2013; PEREZ, 2013; see also PISANO; SHIH, 2009; 2012). Third, although agreeing greatly with the Entrepreneurial State argument, some authors emphasize that a large part of learning occurs during production and defend the role of ‘dumb’ policies such as protectionism and tariffs aimed at keeping domestic firms in activity. These authors also recognize the role of coordination between macroeconomic and industrial policies and that of the state as a ‘manager’ of conflicts inherent to development (CHANG; ANDREONI, 2020).

In the realm of public policy, this return seems to have come in two waves. First, after the 2008 global crisis, there was a strong action of governments seeking to recover the economies of their countries (e.g. the *American Recovery and Reinvestment Act of 2009*), and a strong mistrust in the market as a self-regulating mechanism. This led several observers to believe there would be a return of interventionism. However, what was seen a few years later was the victory of the argument that the economies in trouble were the ones that had irresponsible governments that had spent too much. The solution that predominated was austerity policies – as could be witnessed in the case of Greece and other European countries.

The second wave is more recent, and has become more salient with the publication of several industrial strategies by national governments, such as the German ‘New High Tech Strategy’ published in 2014, the Chinese strategy ‘Made in China 2025’ published in 2015, and the British ‘Industrial Strategy’ published in 2017, among others. In these documents, innovation is sometimes seen not as

an end in itself, but as means to accomplish greater societal objectives, such as population ageing, urban mobility, and climate change. In this sense, scholars have begun to analyse them as a new type of ‘mission-oriented policies’ (cf. FORAY; MOWERY; NELSON, 2012; MAZZUCATO; PENNA, 2015; MAZZUCATO, 2018), in which the objectives are not to accomplish technological feats (such as putting humans on the moon), but to accomplish socio-environmental goals, such as mitigating climate change.

In this context, our contribution to this debate is in analysing what these most recent (second wave) policy documents reveal about the reasons behind the resurgence of industrial policy, and what is ‘new’ about them in terms of policy instruments.

3. Methodology

3.1 Policy-cycle and document analysis

Existing industrial policy classifications (such as FERRAZ; DE PAULA; KUPFER, 2013; WEISS, 2011; BENHASSINE; RABALLAND, 2009; WARWICK, 2013; ANDREONI, 2017) are limited in their ability to fully grasp the complexity and the dynamic aspect of policies. In general, they tend to only focus on policy programmes or instruments, ignoring that these represent the end of a complex process involving several dimensions, such as the diagnosis of the problem, the justification for state intervention, the bigger ambition or ‘vision’ (which implies value judgements), the policy structure, and the implementation strategy. In addition, they fail to address the fact that policy formulation is also a complex political process, in which several political voices are heard, and many others are not (PROCHNIK *et al.*, 2015).

Moreover, although industrial policies are public policies, there is hardly any dialogue between the industrial policy literature in economics and the public policy literature (such as BEMELMANS-VIDEC *et al.*, 2010; KNOEPFEL *et al.*, 2007; DUNN, 2004; WEIMER; VINING, 2010). We argue that bringing insights from the latter, especially the concept of ‘policy-cycle’ (KNOEPFEL *et al.*, 2007) and the methodology of policy documents analysis (WEIMER; VINING, 2010; BOWEN, 2009), is a way of broadening the view of the industrial policy process.

The concept of policy cycle highlights the multiple phases that characterise the policy formulation process. These are: the perception of the ‘problem’; ‘agenda setting’; the formulation of the policy programme and selection of policy instruments; the implementation and solution of practical problems; the policy evaluation; and

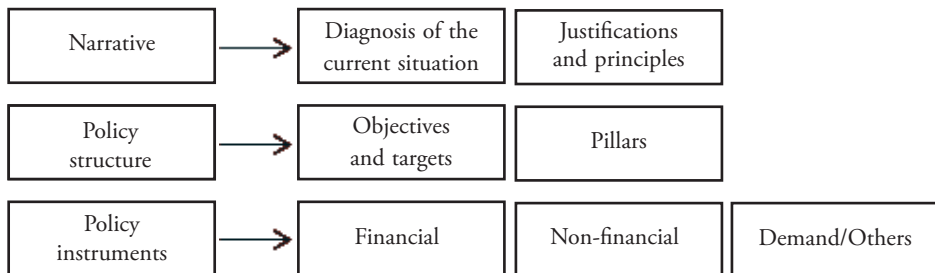
the resumption of the cycle, if the ‘problem’ is not solved (for a more detailed explanation, see KNOEPFEL *et al.*, 2007). We used this concept to create an analytical framework that encompasses the first three phases of the policy cycle.

The method of document analysis² is described by Bowen as involving “skimming (superficial examination), reading (thorough examination), and interpretation” (BOWEN, 2009, p. 32). First, the researcher should undertake a first-pass document review, during which they should demonstrate the capacity to distinguish pertinent information from that which is not pertinent. Subsequently, they should proceed with a thematic analysis, that is, a pattern recognition within the data, with emerging themes becoming the categories for analysis. Finally, using these categories, the researcher proceeds to the interpretation of data. This process was undertaken, as will be described below.

3.2 Analytical framework

Combining findings from our review of the industrial policy literature with insights from selected public policy works, we developed an analytical framework which breaks industrial policies into (1) narratives, (2) policy structure, and (3) policy instruments (Figure 1).

FIGURE 1
Analytical framework



Source: Elaborated by the authors

The first category, Narrative, concerns the story that is told by the policy makers to describe the current situation of the country, and to justify the intervention that is being proposed. The narrative covers aspects such as the diagnosis of the country’s

2 There are a few works that have used document analysis for the research of industrial policies (e.g. CHO *et al.*, 1996; PELLI, 2018).

state of affairs, the rationality for establishing the policy, and the vision towards which the policy is oriented. Kaplan (2002) defends the use of policy narratives as a tool for policy analysis. Here, narrative is understood as an organized form of discourse divided in three parts: a beginning, a middle, and an end. According to Kaplan, by recognizing an ordering plot in – or imposing a plot upon – policy arguments, the analyst can be rewarded with a coherent plot that leads to original insights and conclusions. This is particularly relevant for the present work, given that we are also interested in the justifications – objective and rhetorical³ – of governments for the need of industrial policies.

The second category, Policy structure, covers policy objectives and targets, which refers to the intermediary steps that are proposed in order to achieve the bigger policy ambition, and policy pillars, which concerns the basic policy orientations and areas of government action that are prioritized in order to achieve the policy objectives. In the examined policy documents, these basic policy orientations have several names: pillars, core elements, basic principles, foundations, etc.

The third category, Policy instruments, deserves a careful examination. First, it must be observed that national strategy documents rarely reach the policy instrument level. They usually only mention programmes, if anything at all. Thus, in order to reach the instrument level, one must research each mentioned programme individually and retrieve the information about their instruments from other sources – an effort that was made in this work. Secondly, the proposed sub-categorization of policy instruments is a simplified version of the taxonomy made by Edler and Georghiou (2007). We grouped them in three categories: *Financial instruments* (grants, tax incentives, etc.); *Non-financial instruments* (consulting, training, services, etc.); and *Demand/others* (public procurement, platforms, etc.). The criterion for the choice of the programmes and instruments that will be presented for each country is their appearance in the national strategy documents, which we assume as a sign of their importance.

3.3 Selection of countries and source documents

The national strategies of five countries were chosen: China, Germany, Japan, the UK and the US. Not only are these the five biggest economies in terms of nominal

3 The analysis of the rhetoric behind economic ideas is not new and has been discussed by authors such as McCloskey (1983, 1998), Rego (1996), Gala and Rego (2003) and Paulani (2006). We contribute to this literature by looking at the rhetoric behind recent industrial policy plans. We thank one of the reviewers for highlighting the importance of referring to this strand of the economic literature.

GDP (according to 2017 data from the IMF and the World Bank), they also all recently published well-structured national strategies.

For each of these national strategies, one or more documents were chosen for analysis (see Table 1). These are publicly accessible official documents, made by government agencies or councils, presenting the guidelines, as well as the main programmes and initiatives made in each country.

TABLE 1
Main policy documents used

China	<i>Made in China 2025</i> (State Council, 2015), published in 2015 by the Chinese State Council; Semi-official documents, presented in Merics (2016); News, articles and reports about ongoing policies, found on the website of the State Council, and of other ministries and agencies of the Chinese government.
Germany	<i>New high-tech strategy: innovations for Germany</i> (BMBF, 2014), published by the Federal Ministry of Education and Research in 2014.
Japan	<i>5th science and technology basic plan</i> (Cabinet Office, 2015), published by the Council for Science, Technology and Innovation, Cabinet Office, Government of Japan in 2015; <i>Robot Strategy: Vision, Strategy, Action Plan Robot Strategy</i> (RRRC, 2015), published in 2015 by the Robot Revolution Realization Council, Headquarters for Japan's Economic Revitalization; <i>White Paper on Small Enterprises in Japan</i> (METI, 2017), published by the Ministry of Economy, Trade and Industry in 2017.
United Kingdom	<i>Industrial strategy: building a Britain fit for the future</i> (Secretary of State for Business, Energy and Industrial Strategy, 2017), published in 2017, commanded by the Crown, and signed by the prime-minister and by the secretary of state for business, energy and industrial strategy.
United States	A series of four documents (EOP, 2012a; 2012b; 2014; 2016) elaborated by the Executive Office of the President, in the context of the <i>Advanced Manufacturing Partnership</i> , created in 2012.

Source: Elaborated by the authors

The methodology described above has some limitations, the main one being that it analyses only what is *stated* by the governments. It, therefore, does not detect programmes that are not publicly announced by governments, nor does it discuss so-called ‘implicit policies’ such as macroeconomic policies that may contribute to or undermine industrial and technological development. Despite these limitations, we contend that policy documents are rich sources of information and can provide interesting insights on the countries’ motivations and ambitions. Also, these limitations are minimized given that our analysis is mainly concerned with policy narratives and structure, which are of research interest even if eventually the plans are modified or not fully carried out by the governments.

4. Description of each country's plans

4.1 China

The main recent industrial policy of the Chinese government is the *Made in China 2025*, published in 2015. It goes beyond just promoting automation and the digitalization of industry and incorporates various programmes with the objective of transforming China into a 'manufacturing superpower' by 2049, which marks the 100-year anniversary of the Chinese revolution. It differs from the policies of other countries by being extremely ambitious in the volume of resources applied – considerably larger than in other countries.

It is a policy that seeks the upgrading of value chains, in which the country is already inserted⁴, by pushing for activities of higher technological intensity, while also promoting the substitution of imports in some key components, such as semiconductors. It also includes, to certain extent, sustainability preoccupations, such as pollution and resource efficiency. Table 2 below describes the policy structure and main instruments related to the Chinese plan.

In a nutshell, the Chinese strategy rests on the narrative that the ongoing industrial revolution is a historical opportunity for China to upgrade its 'big but not strong' industry, and to face the simultaneous competition from developed and less-developed countries. Its policy structure is focused on achieving targets of R&D investment, product quality, digitalization, energy and environmental efficiency, and import substitution of key products and technologies. It aims to achieve this through several financial instruments in all levels of government, such as large-scale technology funds, non-financial instruments, such as the creation of National Manufacturing Innovation Centres, and investments in digital infrastructure, and other types of instruments, such as the Pilot Cities and National Demonstration Zones – which are an interesting novelty. Although it is hard to grasp the extent of Chinese industrial policy instruments because of secrecy and the language barrier, it still stands out due to the amount of resources directed to specific initiatives, and the overall bold ambitions of the policy.

4 By the time we are revising this article – June-July 2020 – the world faces the uncertainties associated with the COVID-19 pandemic, which highlighted the vulnerability of relying on value chains for essential products that are dominated by Chinese industries. How other nations will address this vulnerability, including through new industrial policies, is an important question, which however is beyond the scope of the present analysis.

TABLE 2
China: policy narrative, structure, and instruments

Policy narrative	
Diagnosis of the current situation	<ul style="list-style-type: none"> - Historical opportunity: alignment of a technological and industrial revolution and the fast development of China - ‘Two-way squeeze’: developed countries doing ‘manufacturing renaissance’ policies, and developing countries seeking to expand their share in global industrial employment - China’s ‘new normal’: slower growth rates, higher environmental restrictions, growing costs of labour and inputs, and slowdown of investment and exports - Relevance of the industrial sector in China’s economy - China’s industry is ‘big but not strong’: low innovative capacity, low quality of products, few globally famous Chinese brands, low efficiency in the use of resources, pollution, low quality of the industrial infrastructure, low degree of digitalization, and low internationalization of firms
Justifications and principles	<ul style="list-style-type: none"> - Innovation-led development - Quality first - Green development - Structural optimization - Talent-oriented development - Government-led and market-oriented development - Pragmatic planning with a long-term perspective - Holistic advances and breakthroughs in key areas - Independent development open to global cooperation
Policy structure	
Policy objectives and targets	<ul style="list-style-type: none"> - Turn China into a leader among industrial powers, leading the world in innovation, with competitive advantages in many industrial areas, and developing advanced technologies and industrial systems. <p><i>Targets for 2025 (2015 as baseline)</i></p> <ul style="list-style-type: none"> - Internal R&D as a % of operating revenue of manufacturing firms: from 0.88 to 1.68 - Invention patents per billion RMB of operating revenue: from 0.44 to 1.10 - Manufacturing quality competitiveness index: from 83.5 to 85.5 - Manufacturing value-added rate: 4% increase over 2015 - Average manufacturing labour productivity growth (%): 2015-20: 7.5 ; 2020-25: 6.5 - Broadband penetration (%): from 50 to 82 - Digital R&D and design tool penetration (%): from 58 to 84 - Key process control rate (%): from 33 to 64 - Energy consumption decrease per unit of industrial value added: 34% decrease - Carbon dioxide emission decrease rate per unit of industrial value added: 40 % decrease

(continued)

TABLE 2
China: policy narrative, structure, and instruments

(continued)

Policy objectives and targets	<ul style="list-style-type: none"> - Water consumption decrease per unit of industrial value added: 41% decrease - Industrial solid wastes comprehensive utilization ratio (%): from 65 to 79 <p><i>Semi-official targets for domestic market share of Chinese products in 2025 (approximations, Merics 2016):</i></p> <ul style="list-style-type: none"> - New energy vehicles: 80% - High-tech ship components: 80% - New and renewable energy equipment: 80% - Industrial robots: 70% - High performance medical devices: 70% - Large tractors above 200 hp and harvesters: 60% - Mobile phone chips: 40% - Wide-body aircrafts: 10%
Policy pillars	<ul style="list-style-type: none"> - Capabilities in national industrial innovation; - Total integration between informatization and industrialization; - Fundamental industrial capabilities; - Quality and brands; - Green production; - Breakthroughs in ten key areas; - Structural adjustment of industry; - Service-oriented industry and the industry of industrial services; - Internationalization of industry; - Other specific policies
Policy instruments	
Financial	<ul style="list-style-type: none"> - <i>Advanced Manufacturing Fund</i>, CNY 20 billion (EUR 2.7 billion) - <i>National Integrated Circuit Fund</i>, CNY 139 billion (EUR 19 billion) - Several local funding vehicles - <i>Major National Science and Technology Projects</i> - Classification of firms as <i>National Innovative Enterprises</i>
Non-financial	<ul style="list-style-type: none"> - Network of 15 <i>National Manufacturing Innovation Centres</i> (later updated to 40 centres by 2025, at least 5 already in operation) - <i>Innovation 2020</i>, by the China Academy of Sciences - <i>Internet Plus</i>, large investments in digital infrastructure
Demand/Others	<ul style="list-style-type: none"> - Industrial Internet Platforms - <i>Pilot cities and National Demonstration Zones</i>

Source: Elaborated by the authors based on policy documents listed in Table 1.

4.2 Germany

Although commonly associated to the term *Industrie 4.0*, the German strategy, like the Chinese, is actually much broader than just the digitalization of manufacturing. The *High-Tech Strategy* enacted by the German federal government in 2006 has since helped the country to improve its global competitiveness, with increases and consolidation of investments in research, development, and innovation. In 2014, the *New High-Tech Strategy* was created, building on reports from the *Industry Science Research Alliance* (ISRA, 2009, 2013). This strategy's main task was to amplify the scope of previous versions of the *High Tech Strategy*, bringing together all previous solutions in a broader and more interdepartmental innovation policy. As such, new topics and innovation funding tools were included, as well as an expansion of the concept of innovation to include not only technological innovations, but also social innovations, which has society as a central participant.

The strategy rests on the narrative that as a global industrial leader, Germany is under the threat of increasing international competition. As a society, the country also needs to adapt to various large-scale trends such as population ageing, climate change, and digitalization. The main objective of Germany's industrial strategy is to create an environment where new ideas are rapidly transformed into innovative products and services, thus advancing the country's position as the European and global leader in innovation, while generating prosperity and providing a higher quality of life for its population. Achieving these goals entail finding creative answers to the urgent challenges of our time, such as sustainable urban development, sustainable energy, individualized medicine, and the challenges of the digital society. Although it claims to seek the adoption of a systemic view of the entire innovation chain and go beyond promoting technological innovations by also focusing on new organizational solutions and social and service innovations, the instruments proposed are conventional innovation policy tools. These can be financial, such as funding for R&D, SMEs and start-ups, fragile regions, and innovation clusters; non-financial, such as research centres and model factories, networks, SME capability building, and workforce skills development programmes; a single programme of public procurement of innovative products; and some smaller scale innovative programmes. The originality of the policy is found in the emphasis on open research centres and model factories, such as the German Research Centre for Artificial Intelligence and the Mittelstand 4.0 Competence Centres, and on the small-scale innovative

programmes of ‘citizen science’⁵ and ‘real-world laboratories’⁶. Table 3 summarizes the Strategy’s key features, based on our analytical framework.

TABLE 3
Germany: policy narrative, structure, and instruments

Policy narrative	
Diagnosis of the current situation	<ul style="list-style-type: none"> - Germany is one of the global leaders in innovation - The country spends large amounts of resources in innovation, and these have increased over the years - High competitiveness of its small and medium enterprises, the <i>Mittelstand</i> - Intensification of the global competition in innovation with the entrance of new competitors and with the higher flexibility of companies to choose where they will undertake their R&D activities - Low contribution of SMEs for innovation in Germany
Justifications and principles	<ul style="list-style-type: none"> - For innovation to bear fruits, new forms of cooperation that go beyond conventional boundaries (between academic departments, ministries and governmental agencies, industrial sectors and interest groups) are needed - Increasingly, the most important resource is data, in digital form - The idea that society needs to participate in the decisions taken in relation to educational processes, lifestyles, work patterns, and models to follow, because of the big transformations that new technologies and demographic changes will generate in these areas (ISRA, 2009, 2013) - Only implementing technological innovations in productive processes is no longer sufficient. To be innovative today requires going beyond and seeking solutions for the most basic forms of organization of society, such as sustainable consumption and behaviour patterns, and efficient use of resources in production and in lifestyles.
Policy structure	
Policy objectives and targets	<ul style="list-style-type: none"> - A society open to innovation and inspired by new technologies and innovation - A society that sees differences as opportunities, to be achieved through a modern social policy - A sustainable development model, that generates innovations responsibly for the current and future generations - A strong and competitive industrial sector in terms of jobs, with higher dynamism for start-ups - Investing systematically in research and innovation, allowing for a fast translation of research outcomes into products and services - Linking innovation and future technologies to possible social benefits that they may bring. Integrate identification processes of social opportunities and risks associated to new technologies - A healthy and safe work environment for a skilled workforce - Higher gender equality in research and innovation - Intensifying competition in industry and science

(continued)

5 A new concept that uses crowdsourcing for scientific research.

6 A new concept that uses real-world environments, instead of laboratories, as a research infrastructure where scientists and civil society cooperate to create new knowledge.

TABLE 3
Germany: policy narrative, structure, and instruments

(continued)

	<ul style="list-style-type: none"> - Intensifying the consolidation of resources in science, industry, society, and policy making, and use the resulting synergies to increase sustainable competitiveness and prosperity - Expanding cooperation between universities, research institutions, companies, and international partners - Integrating resources with Europe, using opportunities of the Horizon 2020 programme, and contribute to the creation of the European Research Area
Policy pillars	<ul style="list-style-type: none"> - Priority challenges related to value creation and quality of life - Increasing regional, national, and international networking and transference between science and industry - Higher dynamism of innovation in industry (especially SMEs) - Creating an innovation-friendly framework - Transparency and participation of society
Policy instruments	
Financial	<ul style="list-style-type: none"> - Public funding for R&D projects in priority areas (<i>Autonomics for Industrie 4.0, Smart Data Programme, Trusted Cloud Programme, NIP r+Impetus</i>, among others) - Funding conditioned to industry-academia-government cooperation (<i>Research campus</i>) - Programmes for SMEs and start-ups (<i>ZIM, KMU-innovativ, VIP+, SIGNO, go-Inno, EXIST, go-Bio, ERP-Startfonds, coparion, INVEST, High-Tech Grunderfonds</i>) - Programmes for fragile regions (<i>INNO-KOM-Ost, Entrepreneurial Regions, Solidarity Pact II</i>) - Competition for funding between scientific and commercial clusters (<i>Leading Edge Cluster</i>)
Non-financial	<ul style="list-style-type: none"> - Research centres and model factories for the transfer of practical knowledge and capability building (<i>Mittelstand 4.0 Competence Centres, German Research Centre for Artificial Intelligence, Fraunhofer Institutes</i>) - Research Centres integrating basic research and the development of complex systems (<i>German Health Research Centres, Berlin Institute of Health</i>) - Networks or platforms for the diffusion of specialized knowledge (<i>Plattform Industrie 4.0, It's OWL, go-cluster</i>) - Non-financial support for SMEs and start-ups (<i>ZIM, WIPANO, IGF, EXIST</i>) - Skills development and workforce training (<i>JOBSTARTER plus, Fachkräftesicherung competence centres</i>) - Attraction of foreign workforce (<i>Make it in Germany, Research in Germany</i>)
Demand/Others	<ul style="list-style-type: none"> - Public procurement of innovative products and solutions (<i>KOINNO</i>) - Citizen-science programmes (<i>Citizens create knowledge</i>) - Real-world laboratories (<i>Reallabore</i>) - International collaboration in research (<i>EUREKA, EU Research and Innovation Framework, Horizon 2020</i>)

Source: Elaborated by the authors based on policy documents listed in Table 1.

4.3 Japan

Two policies have oriented Japan's recent technological development strategy: the *5th Science and Technology Basic Plan* (CABINET OFFICE, 2015) and the *New Robot Strategy* (RRRC, 2015). The Basic Plans are five-year plans that started in 1996 and have been reissued every five years until today. These plans are elaborated by the Council for Science and Technology and Innovation (CSTI) – formerly the Council for Science and Technology policy (CSTP) –, and by Japan's central government. The *5th Basic Plan*, which lasts until 2020, offers basic directives and objectives for Japan's technological development. Also, a 5-year action plan, the *New Robot Strategy*, was launched in 2015, by the Headquarters for Japan's Economic Revitalization. Specifically, it seeks to advance the field of robotics, which is facing deep transformations and in which Japan has competitive advantages.

The Japanese narrative points to the presence of several social and environmental challenges, as well as a fading prestige and trust in Japan's science, technology, and innovation (ST&I), while also recognizing the country's strength in several areas, such as robotics. The policy aims to go beyond the generation and diffusion of new technologies in industry and seeks to promote significant change in the organization of Japanese society. Moreover, the policy aims at using ST&I in international collaboration to strengthen the fundamentals of ST&I, create an open international system of innovation, and expand the partnerships between industry, academia, and government. Despite these claims, the instruments proposed are quite conventional financial instruments such as public funding and tax incentives for R&D, SMEs, start-ups, and less-developed regions. The most original proposition is the creation of a 'service platform' integrating several productive systems, and the creation of 'Designated National R&D Institutes' that would coordinate innovation efforts. However, the document is very vague and does not explain in greater detail how these would be done. Table 4 summarizes its features.

TABLE 4
Japan: policy narrative, structure, and instruments

Policy narrative	
Diagnosis of the current situation	<ul style="list-style-type: none"> - Recent advances in information and communication technologies that bring about a new paradigm in which information, people, organizations, logistics, finance, etc. are constantly connected at the global level, mutually influencing one another. - Changes in values (from tangible to the intangible) - Social and environmental challenges: population ageing, the increasing occurrence of natural disasters, and challenges related to energy, water, infectious diseases, etc. - Strong international competition - competitiveness is increasingly based on how well firms can use varied knowledge and technology, and in the skills of their highly qualified workers - In the past 20 years, Japan has been capable of establishing a favourable environment for R&D in the country, with the creation and establishment of high-level research centres and systems of human resource management - This, however, has not been translated in productivity gains. Japan's productivity has been lagging behind those of the most advanced countries of OECD, and its growth has been low for many years - Japan's 'superpower' in robotics - Fundamentals of R&D have been weakening (ranking of papers, technological activity, few young researchers), trust in Japanese R&D has been falling, R&D targets have not been met, and universities have been falling behind in human resource management - Collaboration between academia and industry did not reach maturity
Justifications and principles	<ul style="list-style-type: none"> - As the technology frontier advances with convergence of knowledge areas and technologies, it becomes increasingly necessary to act in teams with people from different expertise to generate value - Need to rethink some key areas such as the relationship between science and technology and society, the growth of innovation and open science, and the growing importance of cybersecurity
Policy structure	
Policy objectives and targets	<p><i>5th Science and Technology Basic Plan:</i></p> <ul style="list-style-type: none"> - Sustainable growth and self-sustained regional development - Guaranteeing security for the nation and its citizens and a high quality and prosperous way of life - Facing global challenges and contributing for global development - Sustainable creation of intellectual assets. <p><i>Specific targets:</i></p> <ul style="list-style-type: none"> - Directing at least 4 percent of GDP to total R&D, of which public R&D should be at least 1 percent of GDP - Increase the proportion of full-time university workers younger than 40 years old by 10%, and to increase this proportion by 30% in the future while raising PhD students' incomes

(continued)

TABLE 4
Japan: policy narrative, structure, and instruments

(continued)

<p>Policy objectives and targets</p>	<ul style="list-style-type: none"> - At least 10 percent of the papers published in Japan should be among the 10 percent most cited in the world - Increase the mobility of researchers between firms, universities and Japanese public research institutes by 20 percent - Increase the amount of funding received by industry for collaborative research with universities and national institutes of R&D by 50 percent. - Increase the proportion of patent applications made by SMEs to 15 percent of the total patent applications in Japan <p><i>Robot Strategy</i></p> <ul style="list-style-type: none"> - Make things that are not traditionally considered robots into robots (e.g. automobiles, household appliances, mobile phones, etc.) through advances in sensors and AI technologies - Increase the use of robots in manufacturing plants and in various quotidian scenarios - Creating a society in which new value, convenience and wealth are created through the reinforcement of the global competitiveness in the field of manufacturing and services, and in the solution of social problems. - In summary, create a ‘robot barrier-free society’.
<p>Policy pillars</p>	<p><i>5th Science and Technology Basic Plan:</i></p> <ul style="list-style-type: none"> - Acting to create new value for the development of the industry of the future and social transformation - Facing economic and social challenges - Reinforcing the fundamentals of science, technology, and innovation (ST&I) - Establishing a virtuous systemic cycle of human resources, knowledge, and capital for innovation - Deepening the relationship between ST&I and society - Improving the capacity to promote ST&I <p><i>Robot Strategy</i></p> <ul style="list-style-type: none"> - Robot creativity – detailed reinforcement of robots in Japan - Utilization and popularization of robots - Development and progress of the robotics revolution in global perspective <p><i>Action Plan:</i></p> <ul style="list-style-type: none"> - Establishment of the ‘Robot Revolution Initiative’ - Technological development towards the next generation - Policies over world standards of robotics - Field tests of robots - Human resources development - Implementation of the robot regulatory reform - Expansion of the ‘Robot Award’ - Consideration of a ‘Robot Olympics’

(continued)

TABLE 4
Japan: policy narrative, structure, and instruments

(continued)

Policy instruments	
Financial	<ul style="list-style-type: none"> - Public funding of R&D projects in priority areas (<i>ImPACT, KAKENHI, AMED projects</i>) - Funding conditioned to industry-academia-government cooperation (<i>SIP</i>) - Financial support for SMEs and start-ups (<i>START</i>, several programmes mentioned in the White Paper on Small Enterprises in Japan 2017) - Subsidies and different tax schemes for firms in less-developed regions - Selection of model-companies for financial support (<i>Global Niche Top</i>)
Non-financial	<ul style="list-style-type: none"> - Service platform integrating several productive systems (<i>Super Smart Society Service Platform</i> or <i>Society 5.0 Service Platform</i>) - <i>Okinawa Institute of Science and Technology, Designated National R&D Institutes</i> (early stage of implementation) - Network for the diffusion of specialized knowledge (<i>Robot Revolution Initiative</i>)
Demand/Others	<ul style="list-style-type: none"> - Expansion of the <i>Robot Award</i> - Test-zones for robots

Source: Elaborated by the authors based on policy documents listed in Table 1.

4.4 United Kingdom

The UK policy was published in November 2017 in the document named ‘Industrial strategy: building a Britain fit for the future’. Contrary to other plans, the document is extremely detailed and often mentions the amounts of resources expected for each initiative or programme. The amount of resources proposed is high and will be directed to various different areas such as research, infrastructure, education and training, specific sectors, and regions. The policy document is very complete and its presentation is well organized, revolving around the solution of four Grand Challenges (discussed below).

The strategy is commanded by the British government, but there are also several public and public-private agencies with prominent roles, such as the UK Research and Innovation, the British Business Bank, and Innovate UK. The strategy also mentions an important role for the devolved administrations of Scotland, Wales, and Northern Ireland. It must also be noted that this plan was elaborated before the resolution of the Brexit political imbroglio, so significant changes in the country’s strategies are already occurring, with more changes likely to follow.

In a nutshell, the UK strategy is justified, on the one hand by several global trends such as technological developments, population ageing, clean growth and

energy, and on the other hand, by the perception of several problems in UK's industry and system of innovation, such as sluggish productivity and stark regional inequalities. Its policy objectives include supporting the research system, enhancing workforce skills, investing in infrastructure, improving the business environment, and promoting specific locations. This would be done through several financial instruments such as public funding for R&D, SMEs, start-ups, less-developed regions, skills development and training, and infrastructure; non-financial instruments, such as the creation of research centres, test-beds, training centres, networks, and regulation reform; some demand instruments such as public procurement policies; and some other types of instruments such as campaigns and programmes for international collaboration in research. What stands out as novel in this strategy are some very selective instruments, such as the Sector Deals, and the creation or expansion of some interesting research centres for diffusion of practical knowledge and capability building – the Catapult Centres.

Table 5 presents the Industrial Strategy's characteristics in more detail.

TABLE 5
United Kingdom: policy narrative, structure, and instruments

Policy narrative	
Diagnosis of the current situation	<ul style="list-style-type: none"> - Global transformations: technological developments changing how we live and work, growing share of older people in the population, the way energy is generated and used is changing rapidly - Strengths of the British economy: high employment rate, high attraction of foreign investment in R&D, flexible labour market, high quality of institutions in general - Sectoral strengths: automobile, aerospace, food and drink, creative industries, service sector (financial, professional, and business services), technological strengths (satellites, synthetic biology), world-renowned education system - Weaknesses of the country: sluggish productivity, regional inequalities - Not enough investment in R&D done by the public and private sectors, especially in the development phase - Shortage of skilled workforce and strong interdependence in research between UK and other countries - Low quality and reputation of technical education, regional disparities in education and skill levels - Although the country is an international reference in business environment, problems still persist in the access of firms to finance, the proficiency of managers, and the relationship between high-performing firms and their supply chain - Regional disparities concerning productivity, workforce skills, and infrastructure

(continued)

TABLE 5
United Kingdom: policy narrative, structure, and instruments

(continued)

Justifications and principles	<ul style="list-style-type: none"> - Need for employers, individuals, and governments to work together to develop the necessary skills to work with new technologies - Need to consider broad objectives when designing investment programmes, and these investments should be geographically balanced. - Governments have responsibilities that go beyond promoting competition such as its strategic and leadership role, in coordinating efforts to develop and disseminate new technologies and industries - Governments can make long-term investments that no other agent in academia or the market could do on its own. - The modern Nation-state is seen as the most powerful way of distributing risks, and the British government claims to be ready to take these risks.
Policy structure	
Policy objectives	<ul style="list-style-type: none"> - Putting the UK at the forefront of the data and artificial intelligence revolution - Maximizing the advantages of the global change towards clean growth for the UK industry - Making the UK a global leader in the design of the future of mobility - Using the power of innovation to find solutions for an ageing society
Policy pillars and targets	<p><i>Ideas</i></p> <ul style="list-style-type: none"> - Increase total R&D investment to 2.4 percent of GDP by 2027 - Increase R&D tax credit rates from 11 to 12 percent - Invest £725 million in new ‘Industrial Strategy Challenge Fund’ programmes <p><i>People</i></p> <ul style="list-style-type: none"> - Establish a world-class technical system that reaches the same level as the higher education system of the country - Invest £406 million in STEM skills - Create a new ‘National Retraining Scheme’, with an initial investment of £64 million in digital training <p><i>Infrastructure</i></p> <ul style="list-style-type: none"> - Expand the ‘National Productivity Investment Fund’ to £31 billion, supporting investments in transports, housing, and digital infrastructure - Support electrical vehicles through £400 million in investments in charging infrastructure and another £100 million to extend the ‘Plug-in car grant’ - Spend £1 billion in public investments, including £176 million for 5G and £200 million to encourage local areas in establishing full-fibre networks <p><i>Business environment</i></p> <ul style="list-style-type: none"> - Create ‘Sector Deals’ – partnerships between government and industry seeking to increase the productivity of sectors - Invest £20 billion in innovative and high-potential businesses, including the establishment of a new £2.5 billion Investment Fund incubated at the British Business Bank - Revise the efficacy of measures to promote SMEs’ productivity

(continued)

TABLE 5
United Kingdom: policy narrative, structure, and instruments

(continued)

<p>Policy pillars and targets</p>	<p><i>Places</i></p> <ul style="list-style-type: none"> - Negotiate Local Industrial Strategies based on the strengths and economic opportunities of each location - Create the ‘Transforming Cities Fund,’ which will provide £1.7 billion for intra-city transportation - Provide £42 million for a pilot project named ‘Teacher Development Premium,’ which will test the impact of a £1000 budget for high-quality professional development of teachers in less-developed areas
<p>Policy instruments</p>	
<p>Financial</p>	<ul style="list-style-type: none"> - Funding for R&D and productivity projects (<i>Sector Deals, Digital Railway, Network Rail, ISCF, Faraday Challenge</i>) - Funding conditioned to industry-academia-government collaboration (<i>HEIF</i>) - Funding for SMEs and start-ups (<i>SBRI, Innovation Loans Pilot, Investment Accelerator pilot, Venture Capital Trusts</i>) - Funding mechanisms for less-developed regions (<i>Growth hubs, Local Enterprise Partnerships, Opportunity Areas programme, Strategic School Improvement Fund, Teacher Development Premium pilot, Digital Skills Partnerships</i>) - Skills development and workforce training (<i>Rutherford Fund, Flexible Learning Fund, Unionlearn, Level 3 Maths Support Programme, Further Maths and Core Maths Support Programme, Teaching for mastery maths programme, STEM Ambassador, CREST Awards</i>) - Infrastructure investment funds (<i>National Productivity Investment Fund, Housing Infrastructure Fund, Transforming Cities Fund, Public Works Loan Board, Charging Infrastructure Investment Fund, Clean Air Fund, Air Quality Plan, Digital Infrastructure Investment Fund, Local Full-fibre Networks Challenge Fund, National Security Strategic Investment Fund, TIP, EIS</i>)
<p>Non-financial</p>	<ul style="list-style-type: none"> - Research centres for the diffusion of practical knowledge and capability building (<i>Catapult Centres</i>) - Testbeds for specific technologies (<i>National Satellite Test Facility, 5G Testbeds and Trials Programme, 5GUK test network facility</i>) - Networks for the diffusion of specialized knowledge (<i>Science and Innovation Audits</i>) - Non-financial support for SMEs and start-ups (<i>SBRI</i>) - Non-financial support for workforce training (<i>Apprenticeship Levy, Further Education Centres of Excellence, National Centre for Computing Education, Institute of Coding, National Retraining Scheme, Cyber Discovery programme</i>) - Regulation reform (<i>Smart Systems and Flexibility Plan, regulation reform for autonomous vehicles and digital economy, Centre for Data Ethics and Innovation</i>)
<p>Demand/Others</p>	<ul style="list-style-type: none"> - Public procurement (<i>Crown Marketplace Purchasing Platform, SBRI</i>) - Awareness campaigns (<i>Green is Great</i>) - International collaboration in research (<i>International Collaboration Funds, Official Development Assistance, EUREKA, EU Research and Innovation Framework, Horizon 2020, ERC</i>)

Source: Elaborated by the authors based on policy documents listed in Table 1.

4.5 United States

The Section 102 of the *America COMPETES Reauthorisation Act of 2010* instructed that the technology committee of the National Science and Technology Council (NSTC) should develop a strategic plan to guide the federal programmes and activities in support of the research and development of advanced manufacturing. In June 2011, the *Advanced Manufacturing Partnership* (AMP) was launched. The AMP is, in the words of the government, ‘a national effort bringing together industry, universities, and the federal government to invest in the emerging technologies that will create high quality manufacturing jobs and enhance our global competitiveness’ (THE WHITE HOUSE, 2011). As a result of the creation of the Partnership, a document was launched in February 2012 named ‘National Strategic Plan for Advanced Manufacturing’. Later, in 2014 and in 2016, two other documents were added, evaluating the progress made, and providing additional recommendations. These are the main policy documents analysed here.

The US strategy is based on the narrative that the country has been losing its industrial capabilities in high-technology to other countries, which has been leading to an erosion of its ‘industrial commons’. It also acknowledges that isolated federal policies and programmes cannot deal with the challenges of advanced manufacturing – seen as key to create ‘sticky’ activities that are not easily copied by other countries. The strategic plan thus claims to incorporate intensive engagement from participants of industry, labour, academia, and government at the national, state, and local level. In addition, a central principle of this strategy is a cohesive approach towards research, development, and application of technologies. Despite these bold claims, the instruments proposed are traditional financial instruments, such as funding for R&D, SMEs and start-ups, less-developed regions, and workforce training and skills development; non-financial instruments, such as the creation of research centres, training and skills development programmes, and standards and measurements reforms; and a few public procurement policies. What stands out as original in this strategy is undoubtedly the Manufacturing USA initiative. This is a network of 14 public-private advanced manufacturing institutes, each with a specific technology focus, open to collaboration with firms (especially SMEs), academia and government. They have demonstration facilities and function as a focus-point for capability building and workforce training for cutting-edge technologies.

Table 6 sums up the characteristics of the AMP policies in greater detail.

TABLE 6
United States: policy narrative, structure, and instruments

Policy narrative	
Diagnosis of the current situation	<ul style="list-style-type: none"> - Loss of competitiveness of the country in advanced-technology products (citing Pisano and Shih, 2009) - Traditional federal investments in basic research have not been totally captured by the US industry - Shortage of skilled workforce - Deterioration of the ‘industrial commons’ - Country still ranks well in science, technology, and innovation indexes, but these positions might be lost if measures are not taken to keep ahead
Justifications and principles	<ul style="list-style-type: none"> - Market failures in the more applied stages of research and innovation (e.g. applied research, scale-up and commercialization) create the need for an approach that integrates research, development, commercialization and use of technologies - Recognition that in the past federal investments in research, technology, education, and training have helped to create and accelerate new industries, such as semiconductors, when market forces alone would not have been able to do it - Advanced manufacturing seen as a powerful motor of future economic growth and a way of generating production methods that are more likely to stick to the US, as they are hard to be imitated - Federal investments should take a ‘portfolio view’, and not an individual agency view that ignores investments that could benefit multiple agencies and industries, or the economy as a whole
Policy structure	
Policy objectives and targets	<p><i>National Strategic Plan for Advanced Manufacturing</i></p> <ul style="list-style-type: none"> - To make a more effective use of federal facilities capacity, including public procurement of products at the technological frontier, seeking to increase the investment in advanced manufacturing, specially by SMEs. - Develop and train the workforce for advanced manufacturing and make the education system and training more responsive to the needs of industry. - Create and support national and local public-private partnerships between government, industry, and academia - Adopting a portfolio perspective between the government agencies for investments in advanced manufacturing – a ‘whole-of-government innovation policy’
Policy pillars	<p><i>2014 Report to the President: accelerating US advanced manufacturing</i></p> <ul style="list-style-type: none"> - Enabling innovation: this pillar seeks to establish a National Strategy for Industrial Technology, and to establish and support a National Network for Manufacturing Innovation (NNMI) – later named ‘Manufacturing USA’ - Guaranteeing the talent pipeline: in this pillar, the objective is to alter misconceptions that the public has about manufacturing and connect more the Americans with the skills for successful careers in manufacturing - Improving the business environment: this pillar seeks to expand and exchange solutions for industrial intermediation, and to increase access to capital for established firms and start-ups

(continued)

TABLE 6
United States: policy narrative, structure, and instruments

(continued)

Policy pillars	<p><i>2016 Report on Advanced Manufacturing</i></p> <ul style="list-style-type: none"> - Areas of existing priority: advanced machine-tools, assistive robotics, bio-printing, cybersecurity and additive manufacturing - Areas of future interest: advanced materials, bio-engineering for biomanufacturing and continuous production of pharmaceuticals
Policy instruments	
Financial	<ul style="list-style-type: none"> - Funding for R&D in priority areas (<i>National Nanotechnology Initiative - NNI, Manufacturing Technology Programme – ManTech, Materials Genome Initiative - MGI</i>, among others) - Funding conditioned to industry-academia-government collaboration (<i>STTR</i>) - Funding for SMEs and start-ups (<i>SBIR, America’s seed fund</i>) - Funding for less-developed regions (<i>IMCP</i>) - Skills development and workforce training (<i>GRF, GOALI, PFI, AIR</i>)
Non-financial	<ul style="list-style-type: none"> - Network of research institutes focused on advanced manufacturing technologies (<i>Manufacturing USA – 14 established institutes, expansion to 45 predicted</i>) - Centres of research, technology transfer and demonstration (<i>Manufacturing Extension Partnership institutes, user facilities and centres of technology transfer of the NNI, Integrated Biorefineries, Smart Manufacturing Institute (CESMII), Institute for Collaborative Biotechnologies,</i> - Institutes integrating basic research and complex systems development (<i>ERCs, IUCRCs, STCs</i>) - Facilities for specific sectors or technologies (<i>Synthetic Biology Foundry, Bioreactors for Reparative Medicine Program, Demonstration and Market Transformation Biorefineries, Pharmacy On Demand and Biologically-derived Medicines On Demand</i>) - Networks or platforms for the diffusion of specialized knowledge (<i>NNI, Energy Materials Network, Fuel Cell Technologies Office Database, Development of Modelling Tools for Quality Risk Management</i>) - Non-financial support for the translation of technologies in products and their commercialization (<i>ManTech, Production Assistance for Cellular Therapies III, Biorefinery Commercialization Assistance Program</i>) - Non-financial support for skills development and workforce training (<i>MENTOR, National Career Clusters Framework, Manufacturing Skills Certification System, ETA, Registered Apprenticeship program, American Apprenticeship Initiative, WIA, Right Skills NOW, Make it in America, ATE, TAACCCT, IUCRC, ERC, Advanced Technology Education Centers, Manufacturing USA, Manufacturing Experimentation and Outreach Two</i>) - Standards and measurements reform (<i>NIST</i>)
Demand/Others	<ul style="list-style-type: none"> - Public procurement of early-stage innovative products (<i>Buy America, Defense Production Act Title III</i>) - Opening up of markets for American products (<i>TPP, ITEC</i>) - Incentives to foreign investment in the country (<i>Make it in America Challenge</i>)

Source: Elaborated by the authors based on policy documents listed in Table 1.

5. Analysis

5.1 Narratives

Common issues can be found underpinning all the policy plans analysed. The main one is that all policies were justified by the recognition of the ongoing technological transformations (emergence of potentially ‘disruptive’ innovations), and the need to act in order to seize the opportunities and face the challenges brought by them. Another one is the emphasis on the stronger international competition, mentioned mainly in the German, US, and Chinese policies. Additionally, the tackling of societal challenges (such as climate change, ageing of the population, urban mobility, disruptive changes brought by digitalization, etc.) is also present in the policy narratives of Germany, Japan, and the UK. In the case of China and the US, geopolitical motives are used as justifications for developing and implementing a new industrial policy plan. Lastly, a common justification in all policy plans is the need for a more integrated view of innovation, both in terms of a deeper cooperation between different actors, institutions and fields of knowledge, and in terms of the different stages of the innovation chain (basic research, applied research, development, scale-up, and commercialization). This seems related to the ongoing technological convergence/ ‘fusion’ aspect of advanced manufacturing technologies.

The differences observed seem to stem to a great extent from the different country situations in terms of competitiveness, social challenges, and their different stages in terms of economic and technological development.

In this sense, China stands out from the other countries as it is, on the one hand, economically less-developed than the other countries analysed, while on the other hand, being the country with the highest recent economic growth. China’s plan is therefore a continuation of its techno-economic developmental trajectory. It recognizes the strong competitive pressures (‘from below’ and ‘from above’) that the country is facing, and the severe fragility of the country’s industry in several aspects – including environmental issues – despite the country’s consolidated presence in a vast array of global supply chains. It has perhaps the most ambitious policy in its objectives (aiming to become an industrial global superpower by 2049) and in the amount of resources mobilized. It is also the only country to present, although semi-officially, targets for import substitution.

The German strategy recognizes the country as the technological leader in various areas, especially as a supplier of capital goods and high-tech equipment,

and their policy is directed to investments in new technologies in order to maintain its privileged position in Europe and in the world. The strategy is justified by the intensification of international competition in innovation, by the great changes (economic, technological, demographical, climatic, etc.) that are surging, and by the consequent need for adaptation.

The US plan, in turn, shows preoccupation⁷ with the loss of important sectors and capabilities to other countries, attributing this to the lack of capabilities in the scale-up and commercialization phases of innovations. Thus, its main concern is in developing sectors that contribute to competitiveness and innovation and that are ‘sticky,’ which will help rebuild the country’s ‘industrial commons’. It is in that sense that the focus on advanced manufacturing must be understood.

The narratives of the British and Japanese strategies show some similarities. Both point to a desire to recover a ‘lost prestige’ by seizing the opportunities presented by new advanced manufacturing technologies. Relatedly, both strategies mention sluggish productivity statistics, and problems in their national systems of innovation, although they also recognize their countries’ strengths in several areas. Furthermore, both countries, like Germany, mention several social challenges as justifications for their policies.

5.2 Policy structures

Regarding policy structures, our analysis reveals six main policy orientations, common to all five countries (in a universe of 15 orientations common to at least two of the countries analysed – see Table 7). We identify these orientations from the themes mentioned either in the policy objectives or in the policy pillars of each country. We do not treat them separately because their distinction seems to be mainly a rhetorical feature of the policy documents.

The common orientations are shown in Table 7 below. The letter O represents the policy objectives, and the letter P represents the policy pillars. These can be numbered or not, depending on how they appear in the policy documents. The objectives and pillars of each country are grouped according to two main types: ‘industrial competitiveness’ and ‘grand societal challenges.’

7 The COVID-19 pandemic showed that this preoccupation was warranted, not only for the US but other developed and developing nations as well.

TABLE 7
Objectives and pillars of the national strategies of the selected countries

<i>Orientations present in at least two countries</i>	China	Germany	Japan	United Kingdom	United States
Industrial competitiveness					
1. Incentivizing advanced manufacturing (technological development and integration with industry)	O, P1, P2	P1, P3	P1	O1	O1, P1
2. Increasing expenditure in R&D funding, including basic research	P1, P10	O5, P4	O, P3	P1	O5, P3
3. Deepening industry-academia-government-relations	P1	O11, P2	O, P4, P6	P1	O3, O4
4. Development of workforce skills	O, P10	O7, P4	P3, P3R	P2	O2, P2
5. Promoting SMEs and startups	P10	O4, P3	P4	P4	O1, P3
6. Norms, standards and business environment	P1, P10	O4, P4	P4, P3R	P4	P3
7. Developing backward regions		P3	O1	P5	
8. Translating research results into products/Improving scale-up and commercialization	P1	P2			
9. Internationalization of the industry	P9, P10	P2			
10. Innovation infrastructure			P1R	P3	
Grand societal challenges					
1. Sustainable development/Green economy	O, P5	O3, P1	O1, P2	O2	
2. Ageing of the population		P1	O2, P2	O4	
3. Mobility		P1		O3	
4. Participation of society		O2, P5	P5		
5. Challenges of the digital economy and society / Cybersecurity		P1	P2		
<p>Caption: O = Objective; (Ex: O1 = Objective 1 of the policy) P = Pillar (Ex: P1 = Pillar 1 of the policy); <i>Obs.:</i> In the case of China, the objectives are not ordered. In the case of Japan, the letter R means Robot Strategy (Ex: P2R is the Pillar 2 of the Robot Strategy), and in the 5th Basic Plan, there are some unordered objectives which are the targets mentioned throughout the document.</p> <p>There is no mention in the documents of a hierarchy of objectives and pillars. The order of these, therefore, should not be considered as a relevant factor for analysis.</p>					

Source: Elaborated by the authors

The six common orientations are: (1) incentivizing advanced manufacturing technologies and industries, (2) increasing expenditure and funding for R&D, (3) deepening of the relations between industry-academia-government, (4) development of workforce skills, (5) incentivizing SMEs and start-ups, and (6) updating norms, standards and the business environment.

It is notable that Germany, Japan, and the UK mention societal challenges in their policy structures, and in that sense can be seen as ‘mission-oriented’ policies⁸ (MAZZUCATO, 2018), while the US and China pay hardly any attention to these issues, with the exception of ‘sustainability’ and the ‘green economy’ in the case of China. Indeed, the US strategy is still (explicitly) based on the ‘market failure’ rhetoric, although it could be argued that a type of ‘developmental/entrepreneurial state’ is advanced, in line with the ideas put forth by Pisano and Shih (2009; 2012), which the documents cite.

5.3 Policy instruments

Despite some differences in each country’s policy approach, , five main blocks of instruments were identified: (1) Traditional financial instruments to R&D projects in priority areas; (2) Networks of specialized knowledge; (3) New physical, networked installations/infrastructure for (open) innovation; (4) Specific instruments for SMEs and start-ups; and (5) Instruments for workforce skills development. In general, these are very conventional innovation policy instruments, which contrasts with the way these policies are advertised in the documents – as brand-new policies with innovative instruments. This indicates a contradiction: the governments of the analysed countries acknowledge the existence of problems that require strong governmental actions – and want to appear attentive and responsive to these problems to the general public –, but at the same time are very timid in taking more interventionist actions.

The main novelty in terms of technological policy mentioned by these recent strategies is the emphasis given to open research institutes, with demonstration facilities/zones/regions (or testbeds) that bring together several actors from different areas, often working in networks of institutes of the same type. The creation of these institutes is aligned with the demands presented in the policy narratives for a more integrated view of innovation, seeking to approximate traditionally separated actors.

⁸ Yet again, the COVID-19 pandemic reinforced the trend towards policies to address societal missions – in the case, developing drugs, vaccines and other non-pharmaceutical innovations to deal with the disease.

The Manufacturing USA institutes, for example, provide members with a “network of large, medium and small manufacturers, engineering firms, nonprofits, academic institutions, and local state and federal government partners; shared R&D and intellectual property; access to advanced manufacturing equipment and facilities; collaboration and networking; and workforce development and training” (MANUFACTURING USA, 2020). Germany’s Mittelstand 4.0 Competence Centres provides spaces where “small and medium-sized companies and craft businesses in particular can benefit from digitization through practical examples, demonstrators, information events and mutual exchange experience” (BMW I, 2020). The UK Catapult Centres, in turn, are physical centres where “businesses, scientists, technical specialists and engineers work side by side on late-stage research and development – transforming high potential ideas into new products and services and accelerating adoption to generate economic growth,” by providing “access to world class expert technical capabilities, equipment, and other resources required to take innovative ideas from concept to reality” (CATAPULT, 2020). Although similar public centres of research and technological diffusion have existed in the past, their importance in the countries’ industrial strategies seems unprecedented.

As important as pointing out *what is* present in these policy plans, is to point out *what is not*. If one takes as reference the industrial policies of the mid-twentieth century, it is surprising not to find any mention of tariffs, export and import quotas, state-owned enterprises, and hardly any of development and industrial banks (the existing focus being on private venture-capital and start-up funding), and public investments in general. The small emphasis on demand instruments, such as government procurement policies – a type of instrument that has been receiving a lot of attention in the recent innovation and industrial policy debate (see EDLER; GEORGHIOU, 2007) – is also noteworthy, despite the importance of defence procurement in the US system of innovation, for instance.

Seen this way, these documents reveal that in terms of the broader discussion of the resurgence of industrial policies, what is being proposed is not a full return of the state as in the pre-1970s era. The idea is a role for the state less timid than in the 1990s-2000s, but still very wary of interfering in market mechanisms. The policies are selective, in the sense that they have priority areas, but they are priority areas for support of research and innovation and promotion of public-private cooperation. In this sense, they are much more limited than the old sectoral policies of the mid-twentieth century, which involved protection, public investment, public ownership, and many other instruments that now are either contested by critics, downplayed by

supporters or ruled out by international agreements. The possible exception here is China, where it is much harder to grasp the extent of the relative role of the state, because it is much less explicit in terms of the market-instruments being used. The few policy programmes to which we had access, however, reveal enormous amounts of public resources being deployed with strongly nationalistic objectives.

This refrainment in interventionism seems to derive from the fact that these policies are emerging after decades of ideological domination of the view that industrial policies are by definition ineffective or unfair, which has also led to a reduced 'policy space' for government intervention in the international sphere (CHANG, 2006).

Mazzucato (2018) conceptualizes this new approach as 'picking directions' instead of 'picking winners,' and 'tilting' instead of 'levelling the playing field'. This is a useful way of framing it, but it implicitly accepts the depreciative outlook on the 'old-style' industrial policies (the very idea of 'picking-winners' is highly controversial). Indeed, 'picking directions' to promote certain companies that will survive in a competitive market has always been the ultimate goal of industrial policies. The key difference lies in the range of policy instruments that governments are willing to use: larger now than in the 1990s-2000s, but smaller than in the pre-1970s period.

6. Conclusion

The initial contribution of this work is in developing an analytical framework of industrial and innovation policy documents that builds on ideas taken from the public policy literature. This framework considers not only policy programmes and instruments, but also policy *narratives* and *structures*, leading to a broader understanding of the complexities of the policy process.

By using this framework, this paper contributes to the debate on the resurgence of industrial policies by analysing the narratives, structures, and instruments presented in the policy documents of recent national strategies of science and technology of five leading countries (China, Germany, Japan, the United Kingdom, and the United States). We found that despite several idiosyncrasies, the main common justification for the strategies is the perception of technological opportunities and challenges, especially in new digital technologies. These are seen as opportunities not only for maintaining (or gaining) industrial competitiveness in an environment of increased international competition (the focus of China and the US), but also for solving grand societal challenges such as population ageing and climate change (focus of Germany, Japan, and UK), which in itself is a new phenomenon. State intervention

is then justified as a means to seize these opportunities, as it is understood that the private sector alone is not capable of achieving the desired level of R&D investment, nor of accumulating the necessary capabilities for effective innovation. Emphasis is given to the fact that innovation today requires a new level of collaboration between academia, industry, and government (and sometimes even society), and between traditionally separated fields of knowledge.

Despite these acknowledgements and claims, the instruments proposed are, in general, conventional innovation policy instruments. Our analytical framework then enabled us to identify a misalignment between the rhetoric of the plans calling for new and bold actions, and their proposed actions. While the reasons for this contradiction are open for discussion, our hypothesis is that decades of predominance of anti-industrial policy ideas make it hard for governments to openly propose interventionist policies. Doing so would most likely generate strong criticism both within the country and in the international sphere, or even break international trade agreements. If this hypothesis is true, then promoting a new rhetoric is warranted as a means to re-legitimize industrial policy.

The notable exception in terms of novelty is the emphasis on open research centres (and demonstration zones), which can serve as focus-points for the interaction between different actors. The detailed analysis of the implementation of such initiatives is an important area for future research.

These findings reveal that the industrial policies that are ‘resurging’ are quite different from the old twentieth-century ones. Although they are slightly more active and selective than the ones of the 1990s and 2000s, they are very circumspect in interfering with market mechanisms. While markets have always played an important role as selection mechanisms for firms and technologies (especially for countries engaged in export-led industrialization), the contemporary industrial policies are keen to emphasize their conformance to them.

Furthermore, the few original instruments found point to a movement – in the policy narratives, structures, and instruments – towards an institutional (or organizational) ‘fusion’, meaning the approximation of different areas of knowledge, technologies and actors that until now had limited interaction. This seems correlated with the technological ‘fusion’ aspect of the emerging advanced manufacturing technologies, also noted by OECD (2017) and Kodama and Shibata (2017). Whether technological convergence indeed brings about the need for institutional fusion, and to what extent and by what means, is an area to be investigated by future work.

All in all, we argue that the so-called ‘resurgence of industrial policies’ must be seen with caution. It seems to be less of a return to or vindication of the interventionist policies of the early twentieth century, and more of an initial and incremental transformation of the horizontal policies of the last decades, anchored on a rhetoric that emphasizes both state action and market forces to deal with the complexities of innovation and competitiveness in the 21st century. While these policies are likely less subject to contestation both nationally and globally, their effectiveness is still to be investigated and demonstrated.

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