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Industrial Policy and Sustainable Human Development:

Theories, analytical frameworks and real-world practices

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TABLE OF CONTENTS

INTRODUCTION 4

PAPER 1: Industrial Policy for sustainable human development in the post-Covid19 era 20

PAPER 2: Tracking the SDGs in an 'integrated' manner: A proposal for a new index to capture synergies and trade-offs between and within goals 57

PAPER 3: Industrial policy and societal goals: A new look at the American case 95

PAPER 4: Industry 4.0 policy from a socio-technical perspective: the case of the "Mittelstand 4.0" initiative in Germany 131

PAPER 5: The political economy of places in a sustainable human development perspective: The case of Emilia-Romagna 156

FINAL REMARKS 184

Acknowledgments 191

INTRODUCTION

"Whereas, our argument shows that
the power and capacity of learning exists in the soul already;
and that just as the eye was unable to turn
from darkness to light without the whole body,
so too the instrument of knowledge can only
by the movement of the whole soul
be turned from the world of becoming into that of being,
and learn by degrees to endure the sight of being,
and of the brightest and best of being,
or in other words, of the good."

Plato (375 BC), The Republic - Book VII

As almost the whole world is currently living in the waves of the most dramatic global public health emergency of our time and the consequent economic, social and human crisis touching all key dimensions of our lives, it appears more important than ever to emphasise the power of knowledge and learning for the common good. Indeed, nowadays there is a historic and real opportunity to encourage a transformative resilience and a new directionality for the path of structural change of our economies and societies (Di Tommaso, 2020), in order to pursue the goal of human flourishing and shared prosperity for all (UN, 2015). In particular, the Covid19 pandemic seems offering an opportunity not simply to appreciate the constructive role of public action to keep all people, households and businesses afloat (UN, 2020), but rather more profoundly to rethink and propose a new and different framing to structure government intervention properly to serve the public interest and guide societal development on the desirable path.

In this regard, industrial policy can be considered a central pillar of the recovery strategies, in light also of the momentum gained in the academic and policy-making debate (Cimoli et al., 2009; Bailey et al., 2015; Aiginger and Rodrik, 2020; Chang and Andreoni, 2020; Di Tommaso et al., 2020; Oqubay et al., 2020) about its role in, on the one side, dealing with the prolonged international crisis and the ensuing Great Recession in Western countries and, on the other side, leading the process of industrialization, economic growth and poverty reduction in several emerging countries. This renewed centrality of industrial policy represents a sharp departure from the neo-liberal economic model, which had become entrenched in socio-economic policy-making since the late 1970s, having been mostly affected by the dichotomy between omnipresent government failures vs. ubiquitous market failures to justify old arguments against and for industrial policy. Rather, theoretical advancements from different perspectives in the global debate, along with disruptions in production systems derived from severe global shocks (such as the 2007-2008 financial crisis and the emergence of the Covid19 pandemic in 2020), from globalisation processes (e.g. value chain internationalisation and international division of labour) and from disruptive technological changes (e.g. automatization, digitalization, industry 4.0, and the Internet of things) have put industrial policy back on the centre stage (Chang and Andreoni, 2020). In recent times, many national and

sub-national governments have been clearly promoting actions targeting their industrial systems (Cantore et al., 2020), in order to maintain (and upgrade) production capabilities and jobs, as well as to solve dramatic economic and social problems deriving by extraordinary levels of unemployment, deprivation and poverty.

Indeed, the IMF World Economic Outlook (IMF, 2020) suggests that the Covid19 pandemic will cost the world economy $28 trillion in lost output over the next five years, while the ILO (2020) predicts severe disruption of labour markets for the foreseeable future. Cantore et al. (2020) show that more than half of countries accounting for around 90% of world manufacturing value added experienced a protracted economic downturn over the periods January-March and April-June 2020. In particular, the average decrease in UNIDO's seasonally adjusted Index of Industrial Production (IIP) across countries in March 2020 compared to December 2019 was 5.6%, while the average percentage decrease across countries between March 2020 and June 2020 was 2.5%. However, the latest official statistics for the third quarter of 2020 show a quarter-on-quarter rise of 12.1% in manufacturing output compared to the significant drops of 7.9% and 4.6% recorded in the first and second quarters of the year, respectively (UNIDO, 2020). Still, despite the quarterly recovery, output remains 1.1% down on the same period last year.

These performances vary considerably across countries, regions and industrial sectors.

For instance, China felt the impact of Covid19 earlier during the first quarter of 2020, due to an earlier lockdown. Anyway, its manufacturing output grew by 8.2% year-on-year during the third quarter, already exceeding its pre-crisis level and reverting to previous growth trends. On the other hand, most industrialized and developing economies suffered the largest impact of the economic restrictions in the second quarter of the year, then started recovering soon afterwards. In the third quarter, these groups of economies returned to growth, although they have yet to reach their pre-crisis production levels (UNIDO, 2020). Nevertheless, according to Cantore et al. (2020) IIP score differ across countries even when containment measures are equally stringent, likely due to the effectiveness of the individual countries' economic support policies.

Nearly all industrial sectors are facing a protracted economic downturn, in particular machinery and motor vehicles, leather and wearing apparel and low technology manufactures. However, UNIDO (2020) reported that during the third quarter of 2020, medium-high and high technology industries already registered growth of 0.1% compared to the same period of last year, sustained by positive trends in the production of basic pharmaceuticals (2.6%), computer, electronic and optical products (5.7%) and electrical equipment (4.8%).

Finally, evidence shows that governments are switching focus from short-term emergency measures to help firms survive, towards more medium- and long-term industrial policies that seek to prepare industry for a post-Covid19 scenario.

The reliance on industrial policy lies also in the growing appreciation of its relevance and pertinence to promote and govern a desired structural change of the economy (Bianchi and Labory, 2006, 2011; Chang, 1994; Di Tommaso et al., 2013, Stiglitz and Lin, 2013), by reshaping the industrial structure and the organisational configurations of the production systems, thus setting the economy towards a specific path of structural transformation. In this perspective, industrial policy is also about governing the complex process of institutional building and social change that accompany any process of structural transformation (Chang, 2003; Di Tommaso et al., 2020).

For these reasons, nowadays the scope of industrial policy deals with all elements of contemporary production

dynamics (including, for instance, agriculture and services and their interdependencies with the industrial sector); it extends far beyond the correction of market failures (Peneder, 2017); and it embraces a systemic perspective to be holistically integrated with education and training, research and innovation policy, health policy, employment policy, trade policy, etc. (Aiginger, 2007).

This appears consistent with the enhanced connection between industrial policy and complex societal challenges – even more today due to the pandemic – by concerns over the perceived weaknesses and fragilities of both mature and emerging economies, ridden by productivity puzzle, systemic imbalances, public and private debt burden, economic stagnation, rising inequality and environmental degradation, among others (Aiginger, 2014; Aiginger and Rodrik, 2020; Biggeri, 2020; Di Tommaso et al., 2020; Mehrotra and Biggeri, 2007).

In this regard, it is important to provide a general panoramic on the current scenario based on relevant quantitative information and data, representing a preliminary background to support the arguments proposed in this collection of papers.

In terms of growth and industrial development, Table 1 shows stronger performances by low and middle income countries in annual GDP growth, being constantly above growth rates in high income countries, and by middle income countries in terms of value added per worker in industry (including construction), increasing by 25.6% between 2011 and 2019. The weight of manufacturing value added as percentage of GDP has remained approximately stable at around 15% at world level in the last decade, decreasing by 2 percentage points only in the case of middle-income countries. Moreover, yearly growth rates for GDP and productivity from 1990 to 2019 confirm a strong positive correlation between productivity growth and GDP growth (World Bank, 2020).

Table 1. Recent growth and industrial development performance, 2011-2019

Indicator	Country group	2011	2012	2013	2014	2015	2016	2017	2018	2019
GDP growth (annual %)	*Low income countries*	2,2	2,7	5,6	5,1	2,0	3,8	3,7	3,7	4,0
	Middle income countries	6,0	5,2	5,1	4,5	4,0	4,3	4,9	4,4	3,7
	High income countries	1,9	1,3	1,5	2,1	2,3	1,7	2,4	2,2	1,6
	OECD members	1,9	1,3	1,5	2,1	2,4	1,7	2,6	2,2	1,6
	European Union members	1,8	-0,8	-0,1	1,6	2,3	2,0	2,8	2,1	1,6
	World	3,1	2,5	2,7	2,9	2,9	2,6	3,3	3,0	2,4
Industry, value added per worker (constant 2010 US$)	*Low income countries*	5020,9062	4725,47158	4739,0754	4940,3535	4657,37224	4606,1664	4696,63932	4752,89497	4725,91247
	Middle income countries	14283,4155	14473,1194	15026,6114	15508,8861	15865,5971	16606,221	17192,1596	17591,3443	17946,6036
	High income countries	87219,0738	87340,5573	87945,3251	89332,7986	90769,7148	90861,1798	92396,6333	93095,3667	
	OECD members	79525,7729	79508,9675	80130,6947	80918,1585	81878,6655	81856,7575	83270,8606	83501,7856	
	European Union members	68943,2398	68760,7158	69169,8307	70119,7871	71653,8923	72506,9006	73535,4698	74013,6704	74320,7968
	World	27023,2749	26837,3559	27290,4992	27866,1784	28501,3461	29226,1884	29992,4785	30437,329	25128,9166
Manufacturing, value added (annual % growth)	*Low income countries*									
	Middle income countries									
	High income countries	2,1	-0,2	0,9	2,9	2,5	1,1	3,6	2,6	
	OECD members	2,2	-0,2	1,0	2,7	2,6	1,0	3,6	2,5	
	European Union members	4,8	-2,4	-0,3	3,3	4,2	3,0	4,1	1,9	-0,3
	World	2,8	0,6	1,5	2,8	2,5	1,6	3,9	2,7	
Manufacturing, value added (% of GDP)	*Low income countries*									
	Middle income countries	20,2	19,9	19,4	19,3	19,1	18,7	18,8	18,8	18,5
	High income countries	14,0	13,9	13,8	13,8	14,1	14,0	14,1	14,0	
	OECD members	14,0	13,9	13,8	13,8	14,1	14,0	14,1	14,1	
	European Union members	14,7	14,5	14,4	14,5	15,0	15,1	15,0	14,8	14,4
	World	15,8	15,6	15,4	15,4	15,5	15,3	15,4	15,4	

Source: World Development Indicators, World Bank (last accessed on 13th January 2021)

In terms of social progress, the Human Development Index computed by UNDP (Table 2) shows a significant progress by 23.2% at world level between 1990-2019, particularly marked for developing countries (+33.5%) but quite slower in the last decade.

Table 2. Human Development Index (HDI), 1990-2019

Country	1990	1991	2000	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Developing Countries	0,52	0,52	0,57	0,64	0,65	0,66	0,66	0,67	0,67	0,68	0,68	0,69	0,69
OECD members	0,79	0,79	0,83	0,87	0,88	0,88	0,88	0,89	0,89	0,89	0,89	0,90	0,90
World	0,60	0,60	0,64	0,70	0,70	0,71	0,71	0,72	0,72	0,73	0,73	0,73	0,74

Source: Human Development Report Office, United Nations Development Program (last accessed on 13th January 2021)

However, the overall loss in human development due to inequality is very significant (20.4% at world level in 2019), especially for what concerns income (both in OECD members and developing countries) as well as specifically in education for developing countries.

Table 3. Inequality-adjusted Human Development Index (IHDI), 2019

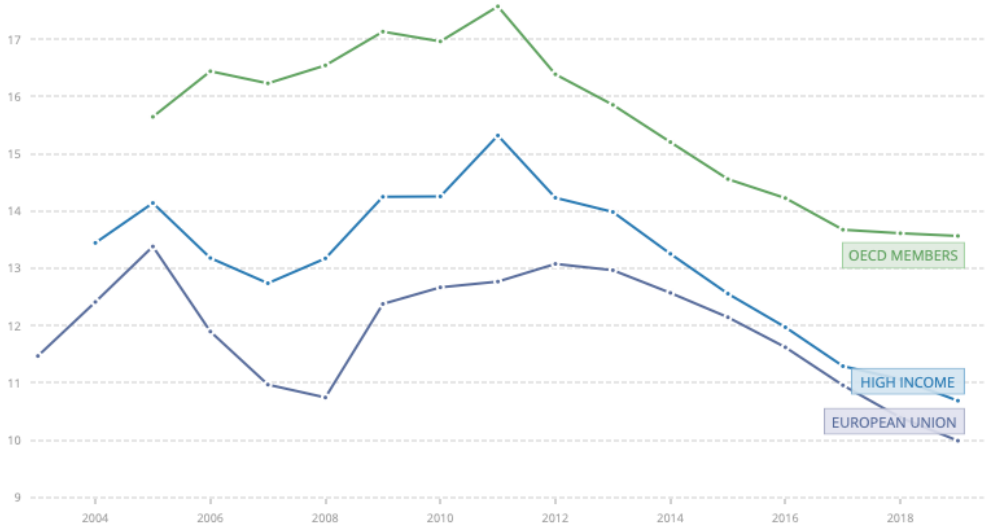
	HDI	Inequality-adjusted HDI		Inequality in life expectancy	Inequality in education	Inequality in income
Country	*Value 2019*	*Value 2019*	*Overall loss (%) 2019*	*(%) 2015-2020*	*(%) 2019*	*(%) 2019*
Developing countries	0,689	0,535	22,4	16,7	25,5	24,6
OECD members	0,900	0,791	12,1	5,5	7,6	22,2
World	0,737	0,587	20,4	14,7	22,1	23,8

Source: Human Development Report Office, United Nations Development Program (last accessed on 13th January 2021)

Data on the Social Progress Index are equally interesting. As computed by Social Progress Imperative (2020), overall social progress is advancing across the world (from 60.63 in 2011 to 64.24 today). On average, today the world scores highest on Nutrition and Basic Medical Care (84.63) and Access to Basic Knowledge (75.18), while it performs worst on the Opportunity dimension, particularly on Inclusiveness (39.25) and Environmental Quality (36.87). Despite the overall progress, Personal Rights and Inclusiveness have regressed since 2011, and there has been stagnation in the areas of Personal Safety and Access to Basic Knowledge. It is interesting noting that GDP per capita does not completely explain social progress, as countries achieve divergent levels of social progress at similar levels of GDP per capita.

Moreover, another relevant social indicator refers to NEET (youth not involved in education, training and employment) as a proxy for social exclusion and vulnerability, whose level (Figure 1) is still above 10% in high income countries though substantially decreasing after having reached its peak in 2011.

Figure 1. Share of youth not in education, employment or training (NEET) - % of youth population, 2013-2019

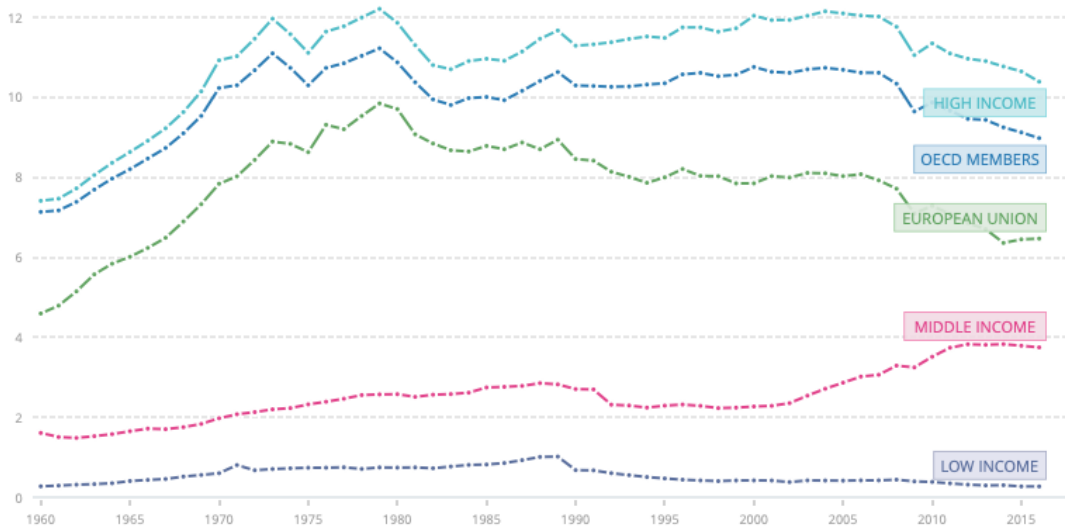


Source: World Development Indicators, World Bank (last accessed on 13th January 2021)

Finally, in terms of environmental degradation, data on emissions are illustrative of the emergency of the situation. According to the World Bank (2020), greenhouse gas emissions have risen from less than 3 gigatonnes per year in 1850 to more than 50 gigatonnes today and, under currently implemented policies, they are expected to reach 55–58 gigatonnes a year by 2030. Figure 2 shows that CO2 emissions per capita are increasing in middle income countries and, though having decreased in high income, OECD and EU countries between 2010-2015, their level is still very high.

Despite national pledges of reduction and lower economic activity due to Covid19 in 2020, this increase will slow only slightly, and thus current mitigation commitments are inadequate to meet global targets, with potential devastating effects, especially on the most vulnerable countries and people, in the medium and long term.

Figure 2. CO2 emissions (metric tons per capita), 1960-2016



Source: World Development Indicators, World Bank (last accessed on 13th January 2021)

Taking into account the current scenario, it seems fundamental to reflect on the role of government intervention on the production dynamics.

While, traditionally, industrial policy has been foremost aiming at enhancing industrial productivity and competitiveness (Peneder, 2017), in recent times it has been increasingly related to the issues of equity and sustainability (UNIDO, 2017; Stiglitz, 2017), with a progressive connection with the notion of inclusive growth (World Bank, 2009; Turok, 2010) and green growth (Altenburg and Assmann, 2017; Rodrik, 2014). This has been contributing to partially pushback against the market-fundamentalist approach, especially due to its limited contribution to delivering long-run, inclusive and sustainable prosperity (Bailey et al., 2015). Within this perspective, new priorities and challenges characterise the overall debate on industrial policy, especially in relation to health, employment and environmental protection, as well as to the social dimensions of inclusiveness, cohesion and human rights within national and local societies. In other words, it switches the attention from what failure industrial policy must rectify, to what it aims to achieve in terms of structural transformation of the economy and society. A similar framing has been gaining momentum also on research and innovation policy, conceiving it in a more systemic and dynamic manner to drive transformative change towards sustainable development (Capriati, 2017; Schot and Steinmueller, 2018; Mazzucato et al., 2019; Prota, 2019; Biggeri and Ferrannini, 2020).

All in all, industrial policy is increasingly conceived as a vehicle to achieve broader societal goals of nations or regions (Di Tommaso and Schweitzer, 2013) for the sake of long-run collective interest (Aiginger and Rodrik, 2020), placing on centre stage the societal development vision underlying its design and implementation and the sustainability of structural change (Di Tommaso et al., 2020).

Talking about industrial policy today – especially, but not exclusively, when linked with broader societal challenges – entails recognising that partial interests by multiple stakeholders shape industrial development processes at all levels (Andreoni et al., 2019). In other words, a multilevel governance approach is required, being conceived as the novel form of public policy-making stemming from the existence of "overarching, multi-level policy networks" (Marks et al., 1996, p. 167) and replacing the vertically hierarchical nation-state model.

The multilevel governance of industrial policy is characterised by two dimensions, i.e. vertical and horizontal.

The former dimension (i.e. vertical) entails that industrial policy requires coherent actions at different levels of government – namely regional, national and supranational – along with the micro level of firms and other economic actors. Indeed, many authors (e.g. Di Tommaso et al., 2013 and Barbieri et al., 2020 for the case of Southern China; Landesmann and Stöllinger, 2020, Mosconi, 2015 and Prota et al., 2020 about the European Union; Biggeri, 2020 about BRICS countries; Pietrobelli, 2019 on Latin America) have robustly assessed how the local and regional dimension of industrial policy (Bellandi and Di Tommaso, 2006) plays a major complementary role to the macro-level policy arena, also building on the extensive literature on industrial districts (Becattini et al., 2009) and clusters (Porter, 1990; Lazzeretti et al., 2014). Moreover, supranational institutions (e.g. the European Commission), international financing institutions (e.g. the World Bank, the International Monetary Fund) and international organisations (e.g. UNIDO, UNCTAD, UNDP) have long affected industrial development processes and industrial policy practices building on different theoretical approaches and development visions. Therefore, a holistic perspective needs to take into account the vertical interrelations of (dis)alignment and (in)consistency between industrial policy at each governance level.

The latter dimension (i.e. horizontal) entails that many actors within each specific society are important in simultaneously shaping productive capabilities and affecting the design and implementation of industrial policy, e.g. firms, non-governmental organizations, professional associations, industry associations, regulatory agencies, research centres and academic institutions, public institutions, etc. (Biggeri and Ferrannini, 2014; Andreoni and Chang, 2017). This argument is also embedded in Becattini's (2015, p. 36) idea of 'productive chorality' as "something constituted by a thousand institutional figures (ranging from families to firms to local government to religious rituals, and more) and by cultural entities (e.g. para-productive institutions, social care provision, sports activities, and more)", making up an underlying cultural background upon which both individual and collective governance decisions depend. Anyway, there are multiple ways and configurations in which the different and sometimes diverging partial interests of industrial policy actors can find an expression compatible with the vital conditions and viability of the system (i.e. in line with a systemic interest) (Cardinale and Scazzieri, 2020). This represents a necessary condition for each group's and stakeholder's pursuit of its own interest, which does not (necessarily) reflect a normative commitment to some definition of collective interest (Cardinale, 2018). All in all, contemporary industrial policy requires enhancing the relations of coordination and alignment across vertical governance levels, as well as among horizontally independent but functionally interdependent actors, in order to converge towards a shared objective of inclusive and sustainable industrialisation and steer the continuous co-evolution of the industrial, economic and social structure of national and local societies.

This multi-level perspective finds even stronger support today in light of the Agenda 2030 for Sustainable Development adopted by the United Nations in 2015 (UN, 2015). It represents the new universal global Agenda composed by 17 Sustainable Development Goals (SDGs) and 169 targets, requiring an innovative multi-level governance approach that goes beyond the traditional scope of the nation-state model in favour of a vertical alignment (among various levels – i.e. international, national, regional, local) and horizontal engagement (between public, private and social actors) with a view of policy coherence towards a common vision (Biggeri and Ferrannini, 2014).

In general terms, the Agenda 2030 balances the three dimensions of sustainable development – economic, social and environmental – and it advocates for building a healthier, safer, fairer and a more prosperous world, whose urgency has appeared clearly since the Covid19 pandemic (UN, 2020). As for industrial policy, it dedicates specific attention to SDG#8 "sustained, inclusive and sustainable economic growth" (especially through full and productive employment and decent work for all) as well as to SDG#9 "sustainable industrialization", conceived as the primary driver in fighting poverty and preventing social polarization (especially through the integration of small-scale industrial and other enterprises into value chains and markets). The universality of the Agenda 2030 makes it critically relevant both for developed countries (see, for instance, the European Green Deal) and emerging economies (see, for instance, the Harmonious Society vision in China) to harness the full potential of industry's contribution for lasting prosperity for all.

Similarly, the Sustainable Human Development paradigm (UNDP, 1990; Haq, 1995; Sen, 1999; Anand and Sen, 1996; Biggeri and Ferrannini, 2014) has challenged development thinking by distinguishing between the means and goals of the development processes and by consistently reconciling productivity, participation, equity and sustainability in a broad societal vision on human flourishing.

Despite these premises, two gaps still appear to affect the current debate on industrial policy.

Firstly, while new analytical frameworks and empirical analysis have been advanced to link industrial policy to ecological parameters, the ones focusing on a more integrated notion of sustainable human development do not seem to have yet reached the same level of sophistication and comprehensive coverage. Indeed, the strong and undeniable nexus between industrial policy and sustainable human development calls for new theoretical and analytical accounts on industrial policy to tackle and avoid poverty, marginalization, social exclusion and environmental degradation at all levels.

Secondly, the theoretical foundations of industrial policies are not fully able to capture and explain the variety of real government intervention models on production dynamics driven by societal goals at national and local level (Di Tommaso and Schweitzer, 2013). Indeed, robust long-term analyses of industrial policy have shown that – despite the neo-liberal rhetoric of its opponents – industrial policy has always been all around in high-income countries (including and primarily in the US, several OECD countries and EU member states), as well as in Asian Tigers and BRICS, whose recent comparative success has given credence to the role of the state in economic development. Moreover, going out of the theoretical debate and focusing on real-world government practices, it is quite common to see industrial policy associated with a quite long list of heterogeneous goals, including meta-economic goals (e.g. unemployment, deindustrialization, protection of domestic productions, territorial unbalances, social inequalities, environment issues, etc.).

Thus, there is wide and increasing dissatisfaction with the relationship between theory and practice on industrial policy, due in particular the inability of established theory to go beyond the simple correction of certain market failures in explaining the reason for a wide range of interventions of our present.

What is still needed is a holistic policy-making approach able to design robust industrial policy for the simultaneous expansion of collective productive capabilities, creation of good quality jobs and socially sustainable structural change, both at national and local level.

Taking together these gaps in the long-lasting literature on industrial policy, the general objective of this collection of papers is to explore why and how national and local governments can shape the future of their societies by promoting industrial policy (within the boundaries of their spheres of intervention) able to simultaneously favour a structural transformation of their economy and increase social progress and collective well-being.

In particular, this collection of papers deals with three specific research questions:

First, what is the theoretical nexus between the debate on industrial policy and its effects in terms of sustainable human development?

Second, how can we measure national development performances keeping into account an integrated notion of the sustainability?

Third, how can industrial policy be designed and implemented by national and local governments as a leverage to steer the structural change of the economy and the society?

All in all, providing preliminary answers to these research questions should be conceived as an impulse to rethinking the theoretical foundations of industrial policy, as well as its design and implementation processes, for a new role in the Covid19 era.

In order to deal with these questions, the research design underlying this collection of papers primarily combines a strong focus on theoretical advancements and new analytical frameworks with a case-study design, leveraging on the mutual engagement between theory and practice of industrial policy keeping and them tied to each other according to real-world conditions.

On the one side, an accurate review on streams of literature about several theoretical approaches that deal – directly or indirectly – with industrial policy characterises this research design, paving the way both for new (re)combinations among them and for new analytical frameworks to reflect on real-world practices of industrial policy.

On the other side, a case-study research design (Yin, 2014) is used to gain in-depth empirical insights on the design, implementation and governance of industrial policy and illuminate the continuous and interactive process of its adaptation by public, private and social actors to steer the structural transformation of the economy and society towards the desired path. Indeed, as argued by Pal (2005, p. 227), to study a case is "not to study a unique phenomenon, but one that provides insights into a broader range of phenomena", as here in relation to the nexus between industrial policy and sustainable human development.

Moreover, the research design devotes attention also to measurement issues to track overall progress towards sustainable development through the use of composite indicators based on new statistical methods and empirical applications.

Based on these premises, this collection of papers is structured as follows.

The first paper ("*Industrial policy for sustainable human development in the post-Covid19 era*") directly deals with the research question about the theoretical nexus between the debate on industrial policy and its effects in terms of human development and sustainability. It starts from the recognition that, within an inevitable revamping attention on the need for government intervention to face the challenges raised by the Covid19 pandemic, industrial policy is appearing as a central piece of the puzzle, as preliminary economic outlooks report the collapse of global activity, uncertain recovery paths, impressive increases in unemployment, rising public and private debt, exacerbated inequality and greater global fragmentation. Indeed, many national and sub-national governments are clearly promoting actions targeting their productive sectors to keep economies on 'life support' and to keep intact the economic infrastructure of society, and the pandemic is emphasizing the strategic nature of certain sectors (e.g. health, agrifood, logistics, ICT).

Nevertheless, in the Covid19 era it appears more urgent than ever to fully place human development, social cohesion and sustainability at the very centre of industrial policy, in order to foster a transformative change in all countries towards a more sustainable and equitable world.

For these reasons, the paper attempts at closing the gap between different strands of literature that, despite having so far evolved separately, provide relevant arguments for a new framing of industrial policy and call for being integrated in a systematic way. Indeed, it is argued that without an appropriate analytical framework with real-world implications, policy-makers would be left without theoretical foundations supporting the design and implementation of industrial policy for social cohesion and socio-economic progress, with the subsequent risk of exacerbating government failures. This represents an undeniable high concern at times requiring extraordinary

interventions to ensure social resilience and measures to protect people, households, ecological systems and business and to steer them towards a new development model.

The second paper ("*Tracking the SDGs in an 'integrated' manner: A proposal for a new index to capture synergies and trade-offs between and within goals*") directly deals with the research question about the measurement of an integrated notion of sustainable development and progress at national level. Its premise lies in the integrated and indivisible nature of the Sustainable Development Goals (SDGs), whose monitoring is an important challenge and strategic opportunity for stakeholders and beneficiaries involved with Agenda 2030 at all levels.
In this regard, Jeffrey Sachs and associates have developed the SDG Index that, combined with a dashboard of indicators, tracks overall progress towards sustainable development at national level. Although their index is robust and permits comparisons across countries, it neglects the 'balanced' and 'integrated' nature of the SDGs, and exhibits well-known problems associated with the use of an arithmetic mean (which assumes perfect substitution between dimensions). To overcome these difficulties, this paper introduces an adjusted 'Integrated Sustainable Development Index' (I-SDI) that can take account of trade-offs and synergies between goals and targets as well as across the economic, social and environmental spheres of sustainable development. This is accomplished by introducing a new aggregation method based on the Multidimensional Synthesis of Indicators (MSI) approach, which overcomes well-known problems associated with replacing the arithmetic mean with the geometric mean (i.e. it makes an allowance for the heterogeneity of dimensions, while avoiding the tendency of the geometric mean to collapse to zero). By taking account of heterogeneity within and between goals as well as across the economic, social and environmental dimensions of sustainable development, and by capturing synergies and trade-offs among indicators, this paper illustrates the value of a more flexible and integrated measure for guiding policy-makers and monitor overall progress.

The following papers directly deals with the research question about the extent to which the design and implementation of industrial policy in practice is a leverage for the structural transformation of the economy and society. Each paper deals with an illustrative case-study – respectively, US industrial policy at federal level in the long-run; a national Industry 4.0 policy with a place-based approach in Germany; industrial policy for a new social cohesion in Emilia-Romagna region (Italy) – to draw insights consistently with the above-mentioned multi-level governance perspective on industrial policy.

The third paper ("*Industrial Policy and Societal Goals: A New Look at the American Case*") analyses the long history of industrial policy in the United States, especially in relation to the role of the US Federal government regarding industrialization as driving the transformation of the economy and society in the long run. In particular, the paper compares industrial policy practices of the Obama (2009–2016) and Trump (January 2017 to January 2019) administrations with the country's historical policy precedents – starting from the days following independence and then tracing government intervention through the various stages of the country's industrialization, highlighting the use of industrial policy to promote an American model of society.

The fourth paper ("*Industry 4.0 policy from a socio-technical perspective: the case of the "Mittelstand 4.0" initiative in Germany*") starts from the premise that Industry 4.0 is currently reshaping the way in which the modern economy produces and sells goods and services, leading to the digitization of production and services, the adoption of new business models and organizations, and the upgrading of the workforce and its skills. This upcoming Fourth industrial revolution, recently speeded up by the outbreak of the Covid19 emergency, is commonly associated not just with important efficiency and productivity gains in production processes, but more generally with a transformation in the economy and society as a whole.

Therefore, given the complexity characterizing the transition towards Industry 4.0, both the academic literature and public institutions have by and large recognized the necessity to implement public policies to influence the rate, direction and deployment of the Fourth industrial revolution. For this reason, this paper analyses an exemplary case of a policy intervention implemented in Germany, i.e. the initiative "Mittelstand 4.0: digital production and work processes", in order to draw empirical insights into how public policy might build momentum and the proper conditions to enable the digital transformation of industrial production.

The fifth paper ("*The political economy of places in a Sustainable Human Development perspective: the case of Emilia-Romagna*") starts from the premise that any industrial policy is not designed – and does not operate – in a vacuum, and thus political economy is required as central type of investigation. This argument appears to be especially relevant at regional level, where implicit and explicit power structures and processes directly shape the progressive transition towards more sustainable forms of industrial development or the regressive enhancement of social fractures and inequalities along with lagging productivity. Moreover, rethinking the political economy of places based on the structural analysis of collective action appears to be especially urgent, as the interplay between economic, social and political processes is pervasive, especially within the industrial policy debate and in light of the current and future uncertain scenario.

Therefore, this paper analyses recent industrial policies for a new social cohesion in the Emilia-Romagna region in Italy, in order to draw empirical insights on how it is possible to design an integrated industrial policy able to simultaneously pursue value-added generation and productivity-enhancement in regional economies, along with inclusiveness and social cohesion.

To conclude, the final remarks resume the main common arguments within this collection of papers and their contribution to the international academic and policy-making debate on the nexus between industrial policy and sustainable human development. Moreover, they acknowledge the general limits of the research design adopted in these papers and thus highlight future potential trajectories for this partially unexplored line of research.

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PAPER 1: INDUSTRIAL POLICY FOR SUSTAINABLE HUMAN DEVELOPMENT IN THE POST-COVID19 ERA

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Abstract

National and local societies all around the world are fighting the most dramatic global public health emergency of our time, which has soon become an economic, social and human crisis touching all key dimensions of our lives. Within an inevitable revamping attention on the need for government intervention to face the challenges raised by the Covid19 pandemic, industrial policy is appearing as a central piece of the puzzle. As production dynamics in every country is highly affected by the crisis, industrial policy is considered part of the response to solve dramatic economic and social problems deriving by extraordinary levels of unemployment, deprivation and poverty. In this paper, we argue that a turning point on the connection between industrial policy, sustainability and development has been reached, highlighting the need to rethink its theoretical foundations as well as its governance and implementation processes for a new role in our post-Covid 19 societies. Therefore, the research question underlying this paper deals primarily with the nexus between the debate on industrial policy and its effects in terms of human development, social cohesion and sustainability. For this reason, we attempt at closing the gap between different strands of literature, whose integrated connection leads to a new analytical framework with real-world implications on the role of industrial policy, not only as tool for productive dynamics, but also as a leverage for sustainable human development. All in all, we aim at contributing to the debate on our post-Covid19 economies and societies in two ways: firstly, by providing a new integrated analytical framework on industrial policy to steer a sustainable structural change of our economies and societies towards sustainable human development; secondly, by identifying preliminary implications on industrial policy governance and implementation, investing in the accurate and transparent design of industrial policy in the post-Covid19 era.

Keywords

Covid19 pandemic; Industrial policy; Government intervention; Sustainable structural change; Sustainable human development

1. Introduction

National and local societies all around the world are fighting the most dramatic global public health emergency of our time, which has soon become an economic, social and human crisis (Guterres, 2020) touching all the key dimensions of our lives. The vibrant international debate on the Covid19 pandemic – and particularly on consequent challenges and opportunities in the medium and long run – has pointed to four arguments that appear central for the discussion about past, present and future trajectories of development and sustainability.[1]

Firstly, there is wide consensus the pandemic is exacerbating several problems of our economies and societies, which were serious and evident well before it (Anand et al., 2020; Fleurbaey, 2020; Mazzuccato, 2020; Sen, 2020; WEF, 2020a). Increasing inequality within and across countries, multidimensional poverty conditions for millions of people and unsustainability of modern production and consumption patterns have coupled with atrophying in the capacity of state institutions (Acemoglu, 2020), resulted from the policy prescription of neoclassical economics (Chang, 2010 and Reinert, 2012, among others) and their unwarranted reliance in the invisible hand of the market.[2]

Secondly, the differential impact of Covid19 in terms of class, generations, social groups, territories and countries is undeniable and it has only begun to reveal itself (Harvey, 2020; OECD, 2020a; Piketty, 2020; Stiglitz, 2020). This particularly concerns the most vulnerable social groups and economies that were already at risk (Venkatapuram, 2020).

Thirdly, the dramatically high human costs inflicted worldwide by the pandemic urge us to make fundamental changes to our economic and social systems (Hepburn et al., 2020; Mazzuccato, 2020; Piketty, 2020). The current state of emergency offers the opportunity to place social resilience[3] and environmental consciousness firmly at the centre stage for decision-making processes, and to redefine the paradigm on the connection between production dynamics, wellbeing and sustainability.

Fourthly, in a similar vein the pandemic seems offering an opportunity to rethink of ''what governments are for" (Mazzuccato, 2020), proposing a new and different framing to structure government intervention properly to serve the public interest. Indeed, the magnitude of the crisis has required governments to step in, shouldering more responsibilities to keeping all people, households and businesses afloat (UN, 2020) through substantial targeted fiscal, monetary, and financial measures aimed at containing the spread of the virus, strengthen health care systems, boost confidence and demand, and limit adverse supply effects (IMF, 2020a; OECD, 2020a).

Within such inevitable revamping attention on the need for public action and government intervention, industrial policy can be considered a central pillar of the recovery strategies. As production dynamics in every country are highly affected by the crisis, industrial policy should be part of the response to solve dramatic economic and social problems deriving by extraordinary levels of unemployment, deprivation and poverty. Many national and sub-national governments are clearly promoting actions targeting their productive sectors to keep economies on 'life support' (WEF, 2020a) and to keep intact the economic infrastructure of society (IMF, 2020a). Moreover,

[1] Since the early seminal contributions (WCED, 1987; Tisdell, 1988; Lélé, 1991; Beckerman, 1992; Anand & Sen, 2000), the debate on sustainability and development has gained momentum, having been decisively enhanced by the adoption of the Agenda 2030 for Sustainable Development (UN, 2015) along with the role played by several academic journals and societies.

[2] Moreover, this was unjustified both in terms of history of economic ideas – e.g. the concept of 'invisible hand' is only once mentioned by Adam Smith (Reinert, 2020 among others) – and in terms of modern economic theory (e.g. Arrow & Hahn, 1971).

[3] See, for instance, Hall and Hamont (2013); Keck and Sakdapolrak (2013).

the pandemic is emphasizing the strategic nature of certain sectors (e.g. health, agrifood, logistics, ICT) and it is forcing a quick shift towards specific types of production (e.g. health-related devices and services).

In this paper we argue that a turning point on the connection between industrial policy, sustainability and development has been reached, highlighting the need to rethinking the theoretical foundations of industrial policy, as well as its design and implementation processes for a new role in our post-Covid 19 societies.

Traditionally, industrial policy has been foremost aiming at enhancing productivity and competitiveness, conceiving an implicit trickle-down approach[4] about its effect on people and quality of life. Here, we discuss to what extent future industrial policy can represent a direct leverage to promote sustainable structural changes based on human development, social cohesion and sustainability, calling back into question the meaning and vision of development (Ingham, 1993; Seers, 1969) toward which both developed and developing countries strive.

In order to achieve this objective, we attempt at closing the gap between different strands of literature that, despite having so far evolved separately, provide relevant arguments for a new framing of industrial policy and call for being integrated in a systematic way. Indeed, we believe that without an appropriate analytical framework with real-world implications, policymakers would be left without theoretical foundations supporting the design and implementation of industrial policy for social cohesion and socio-economic progress, with the subsequent risk of exacerbating government failures. This represents an undeniable high concern at times requiring extraordinary interventions to ensure social resilience and measures to protect people, households, ecological systems and business and to steer them towards a new development model.

The paper is structured as follows. After this introduction, the second section reviews the evolution in the debate on industrial policy and identifies recent discontinuities that are leading to a potential turning point. The third section briefly discusses insights drawing from real-world experiences of industrial policy and potential changes in the post Covid-19 scenario. The fourth section presents the six theoretical pillars that are combined, in the fifth section, in a new analytical framework. The sixth section deals with the implications for industrial policy governance and implementation. The last section concludes with final remarks.

2. The evolution of the debate on industrial policy

2.1. The industrial policy debate

Industrial policy is a wide-ranging concept,[5] whose long-lasting debate has been firmly rooted in the old arguments for and against government intervention, both legitimized and motivated by an opposite rationality of failures (Chang, 1994; Peneder, 2017). Supporters of industrial policy mould the common rationale of ubiquitous market failures (Bator, 1958) to favour the provision of public goods and the management of externalities, as well as to limit the societal risks deriving from imperfect and incomplete markets and from

[4] Such trickle-down approach also almost entirely disregarded the effect working through the network of interdependencies built on the interdependent production processes and the intertwined supply chains for goods and services (Leontief, 1941; Pasinetti, 1977).

[5] See Aiginger and Rodrik (2020) for a careful review of definitions of industrial policy; Reinert (2020) for overview of the historical arguments that have been used to argue for industrial policy in its widest sense; Andreoni and Chang (2018) for the history of economic analysis of industrial policy.

imperfect and asymmetric information, leading to adverse selection and moral hazard. Conversely, opponents of industrial policy stress the arguments of omnipresent government failures, highlighting risks of regulatory capture by partial interests and rent-seekers' pressures, potential government inability to overcome important information asymmetries to properly identify targets and tools to achieve determined goals, and potential internal management problems due to bureaucrats' limited capabilities and personal interests (Krueger, 1974; Tullock, 1967).

In the past decade, the debate has become ''far less ideological and thus more productive" (Chang & Andreoni, 2020, p. 325)[6] and a renewed interest in industrial policy has put it back on the central scene of the academic and policy-making debate in many parts of the world (Aiginger & Rodrik, 2020; Bailey et al., 2015; Chang & Andreoni, 2020; Cimoli et al., 2009; Oqubay et al., 2020). Already before the Covid19 pandemic, a 'industrial policy rejuvenation' (Stiglitz et al., 2013) or 'renaissance' (Mazzucato et al., 2015) was apparent due, at least, to three reasons.

Firstly, the widespread recognition that industrialization processes are essential for the transformation of the economy as a whole, and the subsequently growing appreciation of the relevance and pertinence of proactive industrial policies to promote desired structural changes (Bianchi & Labory, 2006, 2011; Chang, 1994; Chang, 2003; Di Tommaso et al., 2013; Stiglitz & Lin, 2013; UNIDO, 2017) by diversifying and upgrading economies beyond simply freeing up markets (Aiginger & Rodrik, 2020).

Secondly, the necessity for national and subnational industrial systems to reduce the risks and exploit the opportunities connected to globalisation processes – particularly concerning global value chains and the international division of labour (Mehrotra & Biggeri, 2007; Pietrobelli & Rabellotti, 2011; Pipkin & Fuentes, 2017) – and disruptive technological changes – such automatization, digitalization, industry 4.0, and the Internet of things (Bailey et al., 2019a, 2019b).

Thirdly, economic downturns in the aftermath of the global financial crisis and the ensuing Great Recession have partially pushback against the market-fundamentalist approach, which led to mis-investment in the non-tradable sector at the expense of growth-rich tradables (Aghion et al., 2011) and to a limited contribution to delivering long-run, inclusive and sustainable prosperity (Bailey et al., 2015).

Such revamping interest in industrial policy has two facets.

On the one side, it represents a sharp departure from the neo-liberal economic model, which had become entrenched in socio-economic policymaking since the late 1970s. According to Reinert (2006), neo-classical economics operates at a level of abstraction that is too high to capture the key factors recognised long ago as responsible for uneven development and polarisation of the world in growing wealth versus growing poverty and inequality. This has been calling for a qualitatively different way of thinking about economic (and industrial) policy. However, Andreoni and Chang (2018) argue that from the mid-2000s, supposedly original arguments justifying industrial policy are ''rather clumsy translations of old ideas by non-Neoclassical schools into the Neoclassical language", having led to several drawbacks and limitations of such mainstreaming of the industrial policy debate.

[6] For instance, the dichotomy distinguishing between vertical policies, which are geared towards supporting specific sectors, and horizontal policies, which are non-discriminatory and aim to promote an enabling and competitive environment for business growth (Bailey & Tomlinson, 2017), has blurred and it is now acknowledged that horizontal policies must be adjusted to the particular context of an industry and they affect sectors differently, leading towards a more integrated perspective (Peneder, 2017).

On the other side, long-term analyses have shown that – despite the neo-liberal rhetoric of its opponents – industrial policy has always been all around in high-income countries (including and primarily in the US, several OECD countries and EU member states), as well as in Asian Tigers and BRICS, whose recent comparative success has given credence to the role of the state in economic development.

Nevertheless, what it is still widely firm about industrial policy implementation is conceiving it as a technical tool to achieve given goals, which are set from the outside of such debate. In other words, for both policymakers and scholars the salient question is to assess the technical capacity, scale and effectiveness of all types of industrial policies to meet desired objectives. The discussion on these desired societal objectives underlying the design of industrial policy is often overlooked, generally pointing to productivity and competitiveness that in turn would allow for economic growth, higher incomes and socio-economic progress.

2.2. Four recent discontinuities

Relevant discontinuities have recently emerged within the international debate on industrial policy, linked to both theoretical advancements from different perspectives and to the disruptions derived from severe global shocks, such as the 2007–2008 financial crisis and the emergence of the Covid19 pandemic in 2020.

The first discontinuity deals with the scope of industrial policy. Recent conceptualisations and analyses[7] are increasingly arguing that industrial policy is not just restricted to industrial / manufacturing production, but rather deals with all elements of contemporary production dynamics (including, for instance, agriculture and services and their interdependencies with the industrial sector). Moreover, it broadly points to a whole-of-government understanding of industrial policy to be holistically integrated with other complementary policy strands, such as competition, education and training, environment, research and innovation, health, employment, territorial cohesion, etc. (Aiginger & Rodrik, 2020). These arguments underline 'systemic industrial policy' (Aiginger, 2007) as an holistic approach that attends to both demand and supply considerations while encouraging industrial development, and coordinates several policy fields with production processes as its core, while affecting upstream and downstream industries, sectoral change, clusters, and networks (Aiginger & Rodrik, 2020).

The second discontinuity deals with the role industrial policy might have in governing and sometimes driving structural change, which is at the heart of a dynamic process of economic development (Ocampo, 2020). Contributions within the spectrum of new structuralist economics (Lin, 2012, 2017) envisage an explicit role for government intervention to reshape the industrial structure and the organisational configuration of the production system, thus setting economic structures towards a feasible path of structural transformation and making them dynamic and capable of generating new waves of structural change. However, in this perspective industrial policy is also about governing the complex process of institutional building and change that accompany any process of structural transformation (North, 1990; Aoki, 2002; Chang, 1994; Chang, 2003; Di Tommaso et al., 2020a, 2020b).

[7] See, for instance, Di Tommaso and Schweitzer (2013); Andreoni and Chang (2016); Aiginger and Rodrik (2020).

The third discontinuity deals with overcoming the canonical rationalities of failures to justify or contest government intervention. According to Peneder (2017), the peculiar dependence on rationalities of failure[8] originates in the economists' habit to accept hypothetical perfect states as normative benchmarks, inherited from the canon of static welfare optimization. However, these normative benchmarks are ill defined, especially in the dynamic and open systems of a globalized world (Peneder, 2017), which is a feature made even more evident by the global diffusion of the pandemic since its localized emergence in Wuhan.

The last discontinuity switches the attention from what failure a policy must rectify, to what it aims to achieve. This is introduced by linking the structural transformation of economies to the structural transformation of societies, letting new societal and environmental challenges to raise ''questions about industrial policy as it shapes the structure of economic activity more generally" (Aiginger & Rodrik, 2020, p. 3). Undoubtedly, the debate on green industrial policy (Aiginger, 2013; Altenburg & Assmann, 2017; Rodrik, 2014) has been at the forefront of this discontinuity, having explored – both in theory and practice – industrial policy options for managing structural change that accounts for both the productivity and the environmental challenges in a harmonised way, overcoming potential trade-offs (Altenburg & Assmann, 2017). Indeed, placing environmental sustainability on the centre stage and as a potential driver of growth has led industrial policy by several national governments (Mathews, 2020; Rodrik, 2014) and international organisations (e.g. UNIDO, UNCTAD, UNDP) to increasingly deal with fostering new, clean energy technologies, ultra-low carbon technologies and higher energy efficiency, in order to decouple industrial development from resource depletion, pollution and waste production. Nevertheless, an integrated and indivisible concept of sustainability has been recently consolidating (Biggeri & Ferrannini, 2020; Purvis et al., 2019), combining environmental concerns and awareness on planetary limits to growth with both people's inclusiveness, equality of opportunities and wellbeing, and with shared and long-term societal prosperity (including, but not restricted to, income growth). This is clearly embedded in the Agenda 2030 for Sustainable Development (UN, 2015),[9] which embraces ''the so-called triple bottom line approach to human well-being" (Sachs, 2012, p. 2206) by balancing the three dimensions of sustainable development, i.e. the economic, social and environmental. Its universality makes it critically relevant both for developed and developing economies to harness the full potential of industry's contribution for lasting prosperity for all. However, such integrated notion of sustainability does not seem to have been fully reflected yet in the academic debate and in the real-world practices of industrial policy.

If taken together, these discontinuities remark the need for a decisive turning point centred on the recognition that national and sub-national governments can shape the future of their societies by designing and implementing industrial policies able to simultaneously steer a structural transformation of their economies and societies.

[8] Be it either of markets (Bator, 1958), systems (Smith, 2000) or strategic (Cowling & Tomlinson, 2011) for the supporters of industrial policy, or governments for its opponents (Tullock, 1967; Krueger, 1974).

[9] It represents the new universal global Agenda, composed by 17 Sustainable Development Goals (SDGs) and 169 targets adopted by the United Nations in 2015 (UN, 2015). As for the production dynamics and industrial policy, the Agenda 2030 dedicates specific attention to: SDG#8 ''sustained, inclusive and sustainable economic growth", especially through full and productive employment and decent work for all; SDG#9 ''sustainable industrialization", conceived as the primary driver in fighting poverty and preventing social polarization, especially through the integration of small-scale industrial and other enterprises into value chains and markets.

3. Insights from the real-world

The evolution and discontinuities in the international debate on industrial policy are apparent when looking at the variety of government intervention models on production dynamics long before the Covid19 pandemic.

The historical experience of industrial policy in China, the United States, and the European Union is illustrative of the role by governments with regards to industrialization as a more general driver of the transformation of the economy and society in the long-run.[10]

In China,[11] an industrial policy approach characterised by long-term planning and experimentation was envisaged to accompany a gradual shift of the economy and society to a capitalist model with Chinese characteristics, and it is today framed within the 'Harmonious-society' vision.[12]

In the US,[13] despite the continuous emphasis on the strengths of free markets in guiding the country's destiny, industrial policy over time was composed by actions motivated by short-term economic, social, and political necessity, along with more ambitious interventions aiming to achieve more complex structural adjustments and consolidate an American model of the society, as defined by economic powers and interests.

In the EU[14], concerns over production dynamics and de-industrialisation at both aggregate European and member states level[15] have always deserved a central attention, with a varying of policy frameworks on industrial policy over time mostly characterised by a mixed approach (i.e. incorporating both horizontal and sector-specific measures). Recent industrial policy in the European Union has embraced – at least in its mandate and statements – a wider societal perspective, leading to the ''European Green Deal" (EC, 2019) that shapes the new European industrial strategy to transform EU's economy for a sustainable future.

These real-world industrial policy practices highlight – and have in common – the four discontinuities mentioned in the previous section. First, the scope of these experiences of industrial policy has definitively gone beyond a primary or unique attention to the manufacturing sector, and it has been centred on stronger integration among different policy fields. Second, it could be argued from these experiences that industrial policy is primarily about promoting and governing structural change in an attempt to reach a number of different economic and societal goals. Third, the rationales supporting these government interventions go well beyond the simple correction of

[10] Analyses of the industrial policy practices in these three cases become crucial due not only to their undeniable centrality in global production networks, in financial and investment flows, in research and innovation processes and in consumption patterns, but also to their weight and influence in the international policy debate on government intervention and industrial policy. Back in the past as well as in the recent present, their policy experience has often been taken (and in some cases imposed) as a model for developing countries, as in the case of the Washington Consensus (Gore, 2000; Saad-Filho, 2007), the post-Washington Consensus (Fine et al., 2011) or the most recent Beijing Consensus (Bird et al., 2012). Other groups of countries surely have relevant experiences of industrial policy and government intervention governing structural change, shaped by the variety of their capitalisms, government systems and investment capacities (Amsden, 2001). For instance: East-Asia countries, such as Japan and South Korea, to gain and keep global leadership in advanced manufacturing sectors; emerging countries, such as Brazil, India and South Africa, to avoid the 'middle-income trap'; countries characterised by high availability of oil production and/or sovereign wealth funds, such as Saudi Arabia, Russia and United Arab States, for economic diversification; African economies, such as Ethiopia, Botswana and Ghana, to get out of poverty.

[11] See, for instance, Biggeri (2008), Rodrik (2010), Di Tommaso et al. (2013), Di Tommaso et al. (2020b), Ratigan (2017), Cai and Sun (2018), Barbieri et al. (2019a), Barbieri et al. (2019b), Barbieri et al. (2020), Biggeri (2020).

[12] For instance, impressive industrial GDP growth in China has been accompanied by environmental degradation, workers' exploitation, and unbalanced development among Chinese provinces (Biggeri, 2008), requiring policy changes and new strategic targets (Barbieri et al., 2020; Biggeri, 2020).

[13] See, for instance, Block (2008), Di Tommaso and Schweitzer (2013); Mazzucato (2013), Di Tommaso et al. (2020c); Tassinari (2019).

[14] See, for instance, Aiginger (2014); Mosconi (2015); Pianta (2014); Pianta and Lucchese (2016); Eder and Schneider (2018).

[15] Talking about industrial policy in the EU is complicated due to the undeniable importance of competition policy within the single market, the interplay of responsibilities and competences between the supranational, national and regional levels, and the multiplicity of strategies, programmes, frameworks and regulations that are discussed, announced and – to a different extent according to conditions in each member state – implemented and made operational (Landesmann and Stöllinger, 2020).

certain failures. Fourth, industrial policy has been often associated with direct government intervention on production dynamics to promote both economic growth and broader development objectives: namely, growth, competitiveness, productivity, but also job generation and environmental sustainability.

Nevertheless, the ability to fully place human development, social cohesion and sustainability at the very centre of industrial policies in these cases can be questioned (Oqubay et al., 2020). Such questioning becomes even more urgent in the post-Covid19 era (Anand et al., 2020), as preliminary economic outlooks report the collapse of global activity, uncertain recovery paths, impressive increases in unemployment, rising public and private debt, exacerbated inequality and greater global fragmentation (OECD, 2020b; IMF, 2020b).[16]

Among others, the international debate is devoting particular attention to two potential changes in the global industrial and technological landscape.

First, the significant disruptions in GVCs have been amplifying pre-existing concerns over the continued viability of organizing the production of goods and services through GVCs (Oldekop, 2020). On the one side, this is providing stronger support to industrial sovereignty and it may lead to further growing protectionism and nationalism. On the other side, these disruptions are calling for rethinking and improving resilience in global supply chains for the future and reorienting business approaches towards 'risk competitiveness' (instead of cost-competitiveness) (OECD, 2020c; WEF, 2020b). Whatever the future trends, it is clear the restructuring of value chains will have crucial implications not only for the international division of labour, but also for inclusion and sustainability concerns (Oldekop, 2020).

Second, the pandemic has significantly – and in some cases suddenly – accelerated digital transformation in all sectors, showing that advanced technologies and a digital-first mindset to a physical business (whenever appropriate and feasible) are necessary as the global marketplace will require more agile and flexible production systems and supply chains (WEF, 2020c). More in general, data would surely become one of the most significant economic assets, but such an increased reliance on digital assets would also enhance potential issues of digital justice and equity for individuals, firms, communities and countries (Oldekop, 2020).

Moreover, some neglected issues in the theory of industrial policy – namely, according to Chang and Andreoni (2020), reliable commitments under uncertainty, learning in production as ultimate driver of industrial dynamics and influence of demand management on the conduct of industrial policy – would become even more central. Their relevance would potentially increase within a global scenario characterized by increased uncertainty for the next future, new trends and power relations in value chain internationalization processes and revamping attention of fiscal and monetary policies to boost the recovery.

Finally, taking into account these potential implications of the pandemic, Oldekop (2020) argue the need for a global development paradigm able to foster a transformative change in all countries towards a more sustainable and equitable world. They highlight that Covid19 adds even more immediacy to face key sustainability challenges and patterns of inequality through a multi-scalar approach, taking into account the interconnectedness of our economies and societies.

However, when combing the common insights from real-world policy practices with the potential implications the pandemic might bring, we observe the partial inability of established theory in explaining the reasons for a

[16] Among others, organizations like OECD, IMF and IGC are tracking the key policy responses to Covid19 in different areas of the world.

wide range of industrial policy interventions to tackle the societal challenges of our present, especially in light of the debate on the post-Covid19 scenario.

4. The theoretical pillars for a new integrated framework

Based on our previous arguments, it appears necessary to build a new analytical framework with real-world implications to rethink industrial policy as leverage for social resilience and human development, in order to simultaneously advance the academic discussion and inform the policy-making debate at all levels.

Going beyond the mainstream theoretical foundations on industrial policy, our framework draws from six streams of literature and approaches, which a) similarly point to a new directionality on industrial policy, but b) have so far been connected to one another only to a limited extent.

Without any intention of exhaustiveness, for each theoretical pillar we highlight those arguments that are pushing the current and future debate towards a stronger connection between industrial policy, sustainability and development to steer the structural change of our societies. As it will be discussed later, our framework starts from well-known theoretical rationales and foundations of industrial policy (which have been increasingly consolidated in the literature as a result of the recent discontinuities in the debate). Then, it combines them – with each playing a specific role and contribution – and it suggests a unifying linkage with a sustainable human development paradigm as a main element of novelty.

4.1. Goals, targets and tools of industrial policy (Th1)

The current international debate on industrial policy is devoting increasing attention to the relation between goals, targets and tools (Di Tommaso & Schweitzer, 2013), which shapes the government ability to effectively translate general objectives in concrete and specific industrial policy programs (Chang, 1994).

The proper choice of particular targets and tools depends first and foremost on the societal goals to be pursued, and this implies discussing and finding a general agreement about the political priorities to be promoted (Di Tommaso et al., 2020a), and ensuring a consistent relation between goals, targets and tools (Di Tommaso & Schweitzer, 2013).

In this regard, the current debate is shaped by the recognition that economic growth is an essential part, but not the entire structure, of development and that the quality of growth matters, because historical evidence has shown there are different types of unsustainable growth: jobless growth, ruthless growth, voice-less growth, and futureless growth, (UNDP, 1996), but also peace-less growth (Fukuda-Parr, 2007) as well as healthless growth, as the Covid19 pandemic has shown. Moreover, a more comprehensive and societal understanding of competitiveness as a driver of Schumpeterian development is gaining momentum, in which high real incomes are associated with qualitative changes of the socio-economic system (Peneder, 2017).

However, this scenario opens new puzzles for industrial policy, not least because i) societal objectives risk being in conflict with one another, showing the existence of potential trade-offs (Biggeri et al., 2019), and ii) identifying

and selecting particular targets able to respond to societal goals is a controversial issue in any policy design process, whose answer is not easy to attain (Di Tommaso et al, 2020b).[17]

This already complicated framework becomes even more difficult when considering societal priorities different from economic growth, such as the ones made evident by the Covid19 pandemic.

4.2. The new framing of innovation economics and policy (Th2)

Similarly, within the extensive debate on innovation economics and policy, a new framing on research and innovation to accelerate transformative changes towards a more sustainable world is emerging.

According to Schot and Steinmueller (2018), a first framing (emerged explicitly after the Second World War) was based on the premises that science, technology and innovation are the basis for long-term economic growth (by sustaining improvement in factor productivity) and prosperity. Thus, the promotion of public and private R&D – regardless of its focus – through government investments and incentives and the commercialization of scientific discovery through intellectual property rights were necessary to overcome market failures (Arrow, 1962; Nelson, 1959). A second framing (emerged during the 1980s) was based on the premise that interactive learning processes and strong absorptive capacities are necessary to bridge the gap between science, technological discovery and application or innovation. Thus, the building of national, regional and sectoral systems of innovation through public–private partnerships and university-industry linkages become the central pillars of innovation policy focused on overcoming system failures (Etzkowitz, 2008; Freeman, 1987; Lundvall, 1992).

Nowadays, a third and new framing on innovation (emerged in the last decade) is based on the argument that environmental and social goals can be seen as strategic and dynamic drivers of long-term growth and prosperity, in order to drive the system towards the desired structural dynamics of our economies and societies. This is coupled with the need to overcoming transformation failures (Weber & Rohracher, 2012), highlighting that significant advances in technology have not truly resulted in disruptive innovation and systemic change to build more sustainable and inclusive societies for all. Thus, the use of science, technology and innovation for meeting social needs (e.g. ensure public health, ending poverty and reducing inequality in all its forms everywhere) and tackling environmental challenges (e.g. climate change, energy transition and circular economy) gained prominence in policy and academic debate, especially in light of the Covid19 pandemic. Moreover, civil society and citizens became to be conceived not simply as consumers and adopters of innovation, but also as sources of new ideas and solutions, as well as drivers of organizational and business model changes and of new collaborative processes and partnerships for innovation.[18]

A greater directionality in innovation policy fostering a sociotechnical transition towards sustainability is often connected with a mission- or challenge-oriented approach (Mazzucato, 2016), which is operationally translated into new public missions. They sit between broad challenges and concrete projects (Mazzucato, 2018), shaping

[17] According to Di Tommaso et al. (2020a), 'targeting' has most focused on those more dynamic industries that show the best chances to compete in international markets and reach systematically a new large-scale demand for consumption. Nevertheless, the uncertainty connected to the future competiveness and economic performance of different targets remains one of the most critical issues in defining an industrial policy (Lin, 2009).

[18] According to Schot and Steinmueller (2018), the consolidation of this third framing does not imply lessening the importance of – or even abandoning – the previous policy practices, as investment in knowledge infrastructure and R&D continues to be fundamental, as well as strengthening interactions and learning process among all societal actors within national, sectoral, regional and transnational systems of innovation.

and creating markets – rather than just fixing them – to solve concrete societal challenges (Mazzucato et al., 2019).

4.3. Values and institutions in a social economics perspective (Th3)

The literature on social economics[19] and its study of the ethical and social causes and consequences of economic behaviour, institutions, organizations, and policy provides an undeniable support for our analytical framework. Indeed, social economics highlights the relationships between the economy and society, and particularly that ''economic values cannot be separated from social values, and that economic relationships are framed by broader social relationships" (Davis & Dolfsma, 2008, p. 2). Among others, three arguments from this literature have been made apparent by Covid19 pandemic and are worth being highlighted here.

First, despite the neglect in mainstream thinking about the role of societal values, it is increasingly evident that governments adopt belief systems and values that shape and define their policies, thereby influencing the transformation of their economies and societies (Davis & Dolfsma, 2008).

Second, it is fundamental to problematize and engage with the notion and role of the state in economic and societal processes, also by overcoming the separation between the public and the private sphere (Dannreuther & Kessler, 2008) towards a systemic and evolutionary institutionalism perspective (Elsner, 2014).

Third, social economics scholars devote attention on what economic conditions are mandatory for a good society and how can they be achieved, along with how different social institutions contribute to a sustainable, just, and efficient economy. This argument points to a crucial challenge about industrial policy in our current time, that is finding ways to ensure that government intervention is effective and efficient in pursuing societal goals, recognizing that the problem is not *whether* to intervene, but *how*.

4.4. The political economy of industrial policy (Th4)

The discussion on how to intervene – or, in other words, how to design industrial policies – clearly calls the political economy perspective[20] into our framework, as it has long casted doubts on the idea that ''social improvement may derive from a preordained tendency towards social advantage or improvement rather than from purposeful human organization" (Reinert, 2018, p. 137), as emerged through an historical approach to political economy.

Therefore, greater consideration to the structural political economy approach (Cardinale, 2018) and the dynamics of decision-making processes shaping industrial policy should be paid in each context (Andreoni et al., 2019).

Firstly, industrial production systems should be conceived as multi-layered arrangement of interdependencies among a plurality of networked productive units, organisations and institutions, which shape and lead the structural process of production transformation (Andreoni et al., 2019; Landesmann & Scazzieri, 2012a, 2012b). This means that – as Simon (1991) notices – production organisations, not markets exchanges, are the main structures in which people (i.e. the polity and the society) are embedded and, therefore, that the governance of

[19] See, for instance, Pressman (2006); Dannreuther and Kessler (2008); Davis and Dolfsma (2008); Elsner (2014).
[20] See, for instance, Robbins (1981); Dahrendorf (1988); Chang (1994).

these organisations and systems are critical in guaranteeing their reproduction, inclusiveness, and sustainability (Andreoni et al., 2019).[21]

Secondly, industrial policy analyses cannot be reduced to a mere 'technical problem' within a market economy framework, with little (or no) attention – most often due to simplistic 'good governance' and 'good business environment' agendas – to any contextual and political economy considerations (Andreoni & Chang, 2018), including the feasibilities of certain types of structural transformation and appropriateness of target priorities by governments.

Thirdly, framing industrial development as a political economy process (Kalecki, 1976) leads to recognising the political determination and dynamics of economic institutions and policies, which reflect choices made by the society at large or by some powerful groups in the society (Sen, 2013). In any specific industrial policy-making process we should increasingly appreciate the politics that lies behind policy processes, incorporating a sense of the power relations that shape the complex interaction interbetween key players and social groups (Hickey, 2005). Indeed, these players may organise themselves to exercise their agency in order to protect and promote their interests, which may not necessarily be aligned to an envisioned structural change. In this regard, the political settlements framework (Khan, 2017, p. 639) argues ''the distribution of power across organizations affected by particular institutions was usually the most important determinant of the path of institutional change, and the effectiveness of particular institutions."

Therefore, the conflictual aspects of institutions and the conflictual nature of the social transformations should not be ignored. In particular, industrial policy undeniably involves (and opens) manifest and latent conflicts – even more than other policies due to its selectivity nature (Chang & Andreoni, 2020) – that shape how the policy itself, and the society at large, should be organised (Hickey, 2005). Therefore, the political space of interests, power relations and conflicts underlying industrial policies should become the key focus, and the management of conflicts should become a central feature for its successful design and implementation (Chang & Andreoni, 2020), in order to avoid potentially reinforcing horizontal inequalities among social groups, classes and communities due to asymmetries in power structures and struggles.

From these arguments, it follows that industrial policy is also about governing the complex process of institutional building and change that accompany any structural process of production transformation.

4.5. Structural change of the economy and society (Th5)

The analysis of the change in the economic and societal dynamics governed by industrial policy is today expanding. In particular, a new light is shed by the debate on structural change, by combining theory of configurations and dynamics of structural constraints and opportunities, with history of human and policy actions driving the economies and societies along a specific trajectory.

Theories of structural change[22] explain how economic dynamics entails changes across system components, among which the centrality of production processes is pivotal. Recent contributions in the theoretical debate

[21] This resembles also Reinert (2006) theoretical insights on wealth as a product of systemic factors, an argument early established in the industrial policy debate as in Lise (1841) 'national system of political economy'.

[22] According to Cardinale and Scazzieri (2018), classical political economy explains structural change in terms of proportionality conditions determining the way existing structures adjust to temporary or persistent sources of change. In particular, the classical approach to medium-term dynamics sees structural change as a sequence of transformation stages leading the economy from one position to another along a

(Cardinale & Scazzieri, 2018; Quadrio Curzio & Pellizzari, 2018) argue that structural change is to some degree open-ended, because existing structures open up a range of possibilities, but do not determine the specific actions taken therein.

In this regard, Luigi Pasinetti's 'separation theorem' (Pasinetti, 2007) distinguishes between a fundamental level of investigation that addresses the persistent and general features of an industrial economy, and a level of investigation addressing features of economic structures that are more contingent and likely to reflect specific historical and institutional contexts. Such a distinction highlights the open-endedness of structural constraints and the plurality of trajectories the economy may follow subject to any given set of productive interdependencies and institutional conditions, and depending upon the human actions (primarily including industrial policy) undertaken to drive the economy along a specific trajectory (Quadrio Curzio & Pellizzari, 2018).

In other words, interdependencies bring about a range of feasible transformations, which human actions may or may not take up depending on actors' objectives. Therefore, any explanation of structural change is bound to remain open-ended ex ante, because it is the manifold actions on which it is based that will activate a given path of change out of the many that are made possible by economic structures (Cardinale & Scazzieri, 2018; Landesmann, 2018).

In this perspective, promoting economic development means encouraging the structural change of economies[23] governing the interrelated structural change of societies (Di Tommaso et al., 2020a, 2020b). It is undeniable that processes of industrialization or servitization radically change the structure of the economy, but it is equally undeniable that they also modify the shape of the underlying society (UNIDO, 2017). These transformations change the living conditions of individuals, communities, cities and regions, nations. They produce radical modifications in individual and social behaviours, which also drive fundamental alterations in people's needs and demand for goods, services and rights.

4.6. Capability approach and human development (Th6)

The last theoretical pillar provides a vision and direction for the structural transformation of the society industrial policy may contribute to. Indeed, the Capability Approach and Human Development paradigm[24] has been central in robustly challenging a mainstream vision of development, distinguishing between the means and goals and thus questioning the vision of development, its institutions and its processes.

The Capability Approach proposes a fundamental shift from concentrating on the means of living to the actual opportunities of living in itself, that is, human flourishing in terms of expanding the capabilities of people to lead the kind of life they have reason to value. In other words, being a people-centred approach derived from an agency-based and opportunity-oriented theory, it contributes to the conceptualization of the multidimensionality of development, and thus people's real freedoms in daily life are central to the development process.

trajectory driven by some initial disturbance. In contrast, the classical approach to long-term dynamics views structural change as a trajectory in which economic structure is modified because of a persistent change of fundamental parameters.

[23] See, for instance, Baranzini and Scazzieri (1990); Deutsch and Syrquin (1989); Kuznets (1971); North (1990); Syrquin (1988); Syrquin (2008).

[24] See, for instance, UNDP (1990); Sen (1992); Sen (1999); Sen (2009); Nussbaum (2000); Nussbaum (2011); Drèze and Sen (2002); Mehrotra and Biggeri (2007); Biggeri and Ferrannini (2014); Capriati (2017).

It is important to remark that, since the seminal the contributions by Amartya Sen, the capability theories (Robeyns, 2016) have experienced an evolution over time, being still rooted in the theoretical foundations of the approach, but having also moved forward to further expand its original contribution to development thinking. Above all, several capability scholars[25] have contributed to overcoming the CA's excessive individualism and non-negotiable liberalism, by offering methodological, ontological and ethical arguments, arguing for greater attention to groups and collectivities, their capabilities, the structures of living together, in favour of a more communal ethos.[26]

Today, the sustainable human development (SHD) paradigm offers a solid base to systematically integrate the attention on production dynamics typical of industrial policy with the expansion of human capabilities. This is clearly illustrated by the four pillars that characterise SHD on an equal level (Haq, 1995): Equity, in terms of political, economic, social and cultural opportunities, as well as distribution and cohesion; Participation and empowerment, conceived as being active individuals/communities and collective agents of own future; Sustainability, concerning equal intergenerational opportunities in environmental, social and economic terms; Productivity, pursuing an efficient use of local resources within production systems.

In this regard, as clearly expressed by Sen (1990), the dual role of human beings as both agents, beneficiaries and adjudicators of progress, as well as – directly or indirectly – primary means of all production provides a rich ground for confusion of ends and means in planning and policy-making. In Sen's (1990, p. 41) words: "it can – and frequently does – take the form of focusing on production and prosperity as the essence of progress, treating people as the means through which that productive progress is brought about (rather than seeing the lives of people as the ultimate concern and treating production and prosperity merely as means to those lives)".

Therefore, the implications of the capability approach have gone beyond social policies, offering insights also to production processes (Mehrotra & Biggeri, 2005, 2007) and innovation systems (Capriati, 2017), among others. According to both theoretical advancements and empirical evidence, it is clear that, on the one side, human development is deeply affected – both positively and negatively – by production dynamics; and, on the other side, expanding human capabilities, agency and empowerment requires dealing also with industrial development processes. In particular, industrial development and industrial policies are not neutral in terms of human development outcomes, as they deeply affect – either positively or negatively – the expansion of human capabilities.

This argument may lead to the identification of different trajectories of industrial development based on the interrelation between the economic and the social / environmental dimensions. In this regard, Mehrotra and Biggeri (2005) and Mehrotra and Biggeri (2007) highlight the existence of different roads to industrial development, by including the often-neglected dimensions of social outcomes and environmental protection (such as social protection and quality of labour conditions offered in industrial systems). For instance, when many workers receive no social protection and may be exposed to deep health risks, and/or when informal activities are pervasive, industrial development processes might follow a path opposed to human development. Such

[25] See, for instance, Evans (2002); Stewart (2005); Ibrahim (2006); Deneulin and McGregor (2010); Biggeri and Ferrannini (2014); D'Amato (2020).

[26] On these concerns, the debate among the capability scholars is very animated. For instance, according to Robeyns (2016), all capabilitarian theories should be normatively individualistic (thus having the advantage of each and every affected individual as ultimate concern), while D'Amato (2020) relegates ethical individualism to optional status and proposes collectivist capabilitarianism to allow capabilitarian theorizing in explicitly non-liberal socio-political contexts.

perspective indicates that social outcomes, which include access to basic social services, social integration and participation and environmental protection, need to be complemented and not deflected by collective economic efficiency in industrial processes in order to obtain high levels of human development (Biggeri, 2014, 2020).

In line with these arguments, the recent international debate highlights that a holistic view on the industrial environment, composed by all factors of competitiveness and all drivers of productivity, accounts for both growth and human development. In a nutshell, increasing industrial competitiveness and productivity is necessary also the provision of goods and services ensuring and expanding human capabilities, for increasing the standards of living – most notably of those left behind – and for a sustainable use of natural resources.

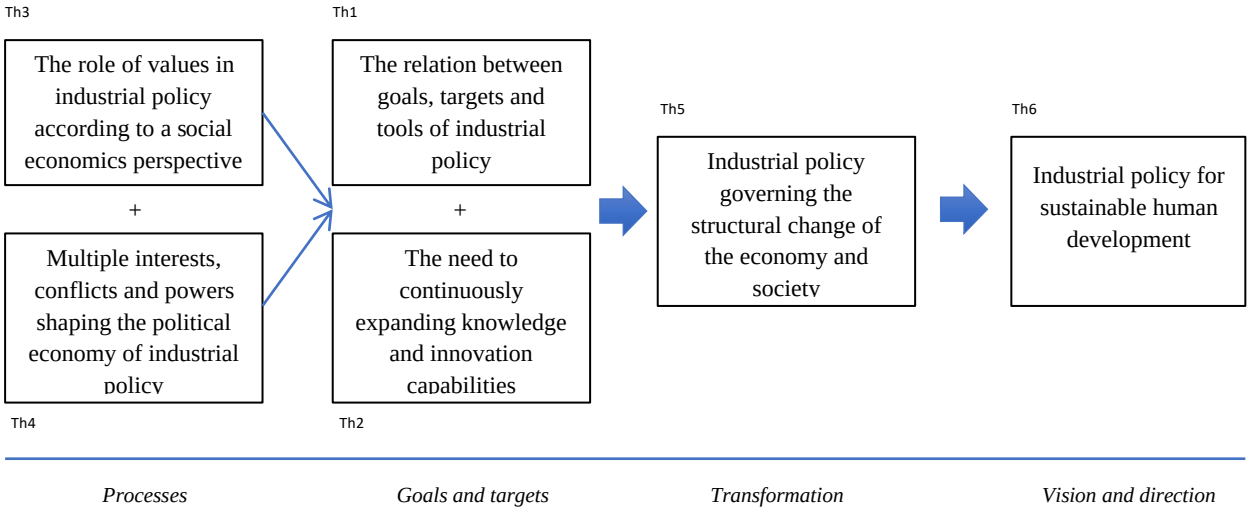
4.7. A new integrated framework

All these different streams of literature are yet to be systematically connected and integrated in a new analytical framework with operational policy implications. Despite their respective theoretical roots belonging to different and often separated schools of thought, we have shown that relevant common arguments on the connection between industrial policy, development and sustainability have emerged from their different angles.

From the increasing debate on the goals, targets and tools of industrial policy (Th1), we learn the importance of ensuring their coherence and consistency to pursue value-based societal priorities. The emerging new framing on innovation policy (Th 2) underlines the need to continuously expand knowledge and innovation capabilities to promote sustainable and inclusive societies by tackling economic, social and environmental challenges. The literature on social economics (Th3) highlights that governments necessarily adopt values, which shape and define the essence of their policies and the capacity of different social institutions at contributing to a sustainable, just, and efficient economy. From the political economy perspective (Th4), we learn the need of a careful consideration of economic, political and social conditions, as well as the importance of the (re)combination of partial interests into a systemic interest underlying industrial policy. From the structural change literature (Th5), we understand that promoting economic development means encouraging the structural dynamics of economies, while governing the interrelated structural changes in the living conditions of people, communities, cities, regions and nations. The human development paradigm (Th6) emphasises that industrial development and industrial policies are not neutral in terms of direct and indirect social and environmental outcomes, and that the increase of economic effectiveness in view of systemic objectives should be primarily directed to expanding human capabilities and ensuring environmental protection.

Therefore, each stream of literature plays a specific function in our framework, as represented in Fig. 1.

Figure 1. The contribution of different theoretical pillars to a new integrated framework on industrial policy



Source: Authors

Therefore, the convergence of these arguments let emerge the main novelty of our framework, i.e. a new directionality for industrial policy in the post-Covid19 era to contribute to promote social resilience and tackle a variety of societal challenges through an expanded role beyond productivity and competitiveness enhancement, which needs to be discussed in details.

5. Combining technical, functionalist and normative perspectives on industrial policy

The connection among the theoretical pillars described in the previous section paves the way for conceiving industrial policy through an integrated framework composed by:

a) a technical perspective on its role as government intervention on production dynamics to pursue given goals;
b) a functionalist perspective on its role to ensure the sustainability of the structural change of the economy and society;
c) a normative perspective on its role to pursue sustainable human development.

The technical perspective has been the prevalent understanding of industrial policy in the long-lasting academic debate, which has engaged with the effectiveness and efficacy of different tools and the appropriateness of different targets, thus mostly focusing on the technical implementation of industrial policy. However, we argue that the functionalist and the normative perspectives deserve more attention for industrial policy to decisively influence the trajectory of economic and social development of any national (or sub-national) system, as well as to contribute to collective and shared efforts for global development (Oldekop, 2020). In this regard, the integration of the technical, functionalist and normative perspectives is fundamental for a turning point on industrial policy, avoiding a detrimental separation and misalignment between them.

5.1. Functionalist perspective on industrial policy

In order to define industrial policies able to address societal challenges at all levels, stronger attention should be paid to the sustainability of structural changes, avoiding increasing vulnerabilities, fractures and inequalities that may hamper the sustainability of industrial development processes themselves.

In this regard, Di Tommaso et al. (2020a) refer to the notion of 'sustainable structural change' as a process of medium- and long-term change in the relative proportions between sectors of the economy, which entails adjustment phases of the economic and social structures,[27] without compromising the proper functioning of the system. As in triple bottom line approach to human wellbeing (Sachs, 2012) underlying the 2030 Agenda for Sustainable Development (UN, 2015), the sustainability of structural change should thus be assessed keeping into equal account its three dimensions: the economic, social and environmental. From the economic standpoint, sustainable structural change could therefore be associated with a path of economic growth, whereby productivity gains in one sector release productive resources for the emergence of other sectors. From the social standpoint, sustainable structural change occurs by preserving the integrity of the social system, namely by acknowledging potential vulnerabilities and governing possible fractures and divergence of interests that could make the system inoperative with respect to overall societal and collective goals. From the ecological standpoint, sustainable structural change should generate a scale of production that does not hamper the capacity of ecosystems and natural resources to continuously regenerate themselves, avoiding environmental collapses, permanent losses and damages.

To put it briefly, in this functionalist perspective industrial policy should be considered as a powerful tool for governing structural changes in view of systemic objectives, influencing the development trajectory in a way such that economic transformations occur without causing the collapse of the entire socio-economic system potentially due to environmental, social or economic vulnerabilities among a plurality of interconnected dynamics. Successful government intervention on production and industrial dynamics must be able to acknowledge and mitigate the potential (ecological, economic and social) threats to system sustainability that could characterize the process of structural change. In this view, the main contribution of industrial policy is enhancing the system's overall ability to evolve in the long run and maintaining a well-functioning and dynamic socio-economic system (Peneder, 2017).

5.2. Normative perspective on industrial policy

The relevance of this functionalist perspective has surely been enhanced by the social and economic collapse of several economic systems due to Covid19. Yet, pursuing a sustainable structural change may not be sufficient in the absence of a unifying and underlying vision of the state of the economy and society to be achieved. Indeed, the pandemic has made evident both the importance of expanding human capabilities and enabling their effective realization into achieved functionings, as well as the priority of public health, freedom of movement, social and family relations, decent work, good housing conditions, quality education and clean environment.

Therefore, in a normative perspective, a new set of principles shaping objectives, targets and tools for industrial policy are needed in order to steer the evolution of the economy and the society ''towards activities that are

[27] See, for instance, Landesmann and Scazzieri (1996); Landesmann and Scazzieri (1990); Scazzieri (2018); Bianchi and Labory (2019a); Bianchi and Labory (2019b).

desirable in economic terms (improving efficiency), in social terms (addressing needs and reducing inequality), in environmental terms (assuring sustainability and preventing climate change)" (Pianta & Lucchese, 2016, p. 6). This recalls the long-lasting debate on the meaning of development in terms of goals and processes (Ingham, 1993; Myrdal, 1970; Seers, 1969) towards which countries strive by means of both public and private strategies and actions.

In our view, the sustainable human development paradigm offers a solid base for this normative perspective on industrial policy, being composed by four pillars on an equal level (Haq, 1995):

i) Equity, in terms of political, economic, social and cultural opportunities, as well as distribution and cohesion;

ii) Participation and empowerment, conceived as being active individuals/communities and collective agents of own future;

iii) Sustainability, concerning equal intergenerational opportunities in environmental, social and economic terms;

iv) Productivity, pursuing an efficient use of local resources within production systems.

In this paradigm, the lives of human beings – that are the agents, beneficiaries and adjudicators of progress – and the sustainability of our societies in terms of Planet, People, Prosperity, Peace and Partnership (Sachs, 2015; UN, 2015) should be the ultimate concern for any government intervention at all levels (Biggeri, 2014), aiming at creating ''a conducive environment for people, individually and collectively, to develop to their full potential and to have a reasonable chance of leading productive and creative lives that they value" (UNDP, 1990, p.1). Thus, policy interventions should focus on those factors that can lead to improve productivity and value-added enhancing processes while reducing inequalities and addressing the environmental tipping points at the same time (Schwab, 2019).

It follows that prosperity should no longer to be confused with the narrow and exclusive goal of economic growth, nor that economic expansion would automatically deliver benefits for all. Rather, a wider notion of societal (shared) prosperity grounded on a vision of sustainable human development – including, but not restricted to, the economic well-being of people – should be embraced in the design, implementation and evaluation of industrial policy in the post-Covid19 era.

5.3. From systemic to collective interest

The difference – yet also complementarity – between the functionalist and the normative perspective on industrial policy is paralleled by the distinction between systemic and collective interest.

On the former, systemic interest is a property of any system (e.g. regional, national or supranational) in which ''interdependencies are such that each interest group has to consider the preservation of the system in order to effectively pursue its own interest" (Cardinale, 2015, p. 203). Indeed, there are multiple ways in which the different and sometimes diverging partial interests of individuals and groups can find an expression compatible with the vital conditions and viability of the system, being able to compromise on suitable weights within the range of configurations compatible with systemic interest (Cardinale & Scazzieri, 2020). Nevertheless, keeping the system viable is a necessary condition for each group's and stakeholder's pursuit of its own interest, but it does not (necessarily) reflect a normative commitment to some definition of collective interest (Cardinale, 2018).

In other words, the systemic interest may not favour a structural change towards a certain vision of development, and it does not (typically) dictate a specific policy. On the contrary, it specifies a range of proportions: it is a constraint on possible outcomes and is therefore (in principle) compatible with a plurality of policies (Cardinale, 2018).

On the latter, collective interest should be conceived in terms of a set of societal objectives to be pursued after identifying systemic interest and its multiple possible realizations depending on the weights assigned to different partial interests (Cardinale & Scazzieri, 2020). The proper definition of an industrial policy requires considering the existence of multiple societal objectives, that are based on values, i.e. depending on the model of society that each community (either supranational, national or regional) desires to pursue, and are supported by different partial interests within a society (e.g. by territories, sectors, classes, generations, etc.) that need to be recombined in a collectively shared vision.

Therefore, a normative societal vision would express the society's fundamental constitutive values and meaning of development and its systemic interest, along with influences external to the system – such as a global development paradigm, global flows of resources and ideas, geopolitics relations – that potentially shape it from the outside.

6. Implications for industrial policy governance and implementation

As remarked, government failures can be even more dangerous when industrial policy is conceived in a more comprehensive way (Di Tommaso et al., 2020a). It is therefore important to embed the discussion on industrial policy governance and management within a comprehensive theoretical framework ensuring full understanding of the conditions for the coherence and effectiveness of policy interventions.[28]

In particular, in this paper our final attention is devoted to industrial policy governance and implementation because: i) they are concerned respectively with creating the conditions for collective action (Olson, 1965; Ostrom, 1990) and making it operational, by extending engagement and commitment to all societal actors; ii) they incorporate an understanding of the multiple loci, layers and levels of action and kinds of variables that can be expected to influence both production dynamics and societal challenges; and iii) their combination makes apparent the link between the 'cognitive act' of formulating what needs to be done and the act of managing its concrete deployment (Hill & Hupe, 2002).

Indeed, in line with Chang and Andreoni (2020, p. 335), the sustainability and inclusiveness of industrial policy will depend on how the power relationships and conflicts (among social groups, firms, forms of capital, countries) will create and support 'productive coalitions' willing to invest in the enhancement of collective productive capabilities to make development processes more sustainable and inclusive, for the sake of both systemic and collective interest.

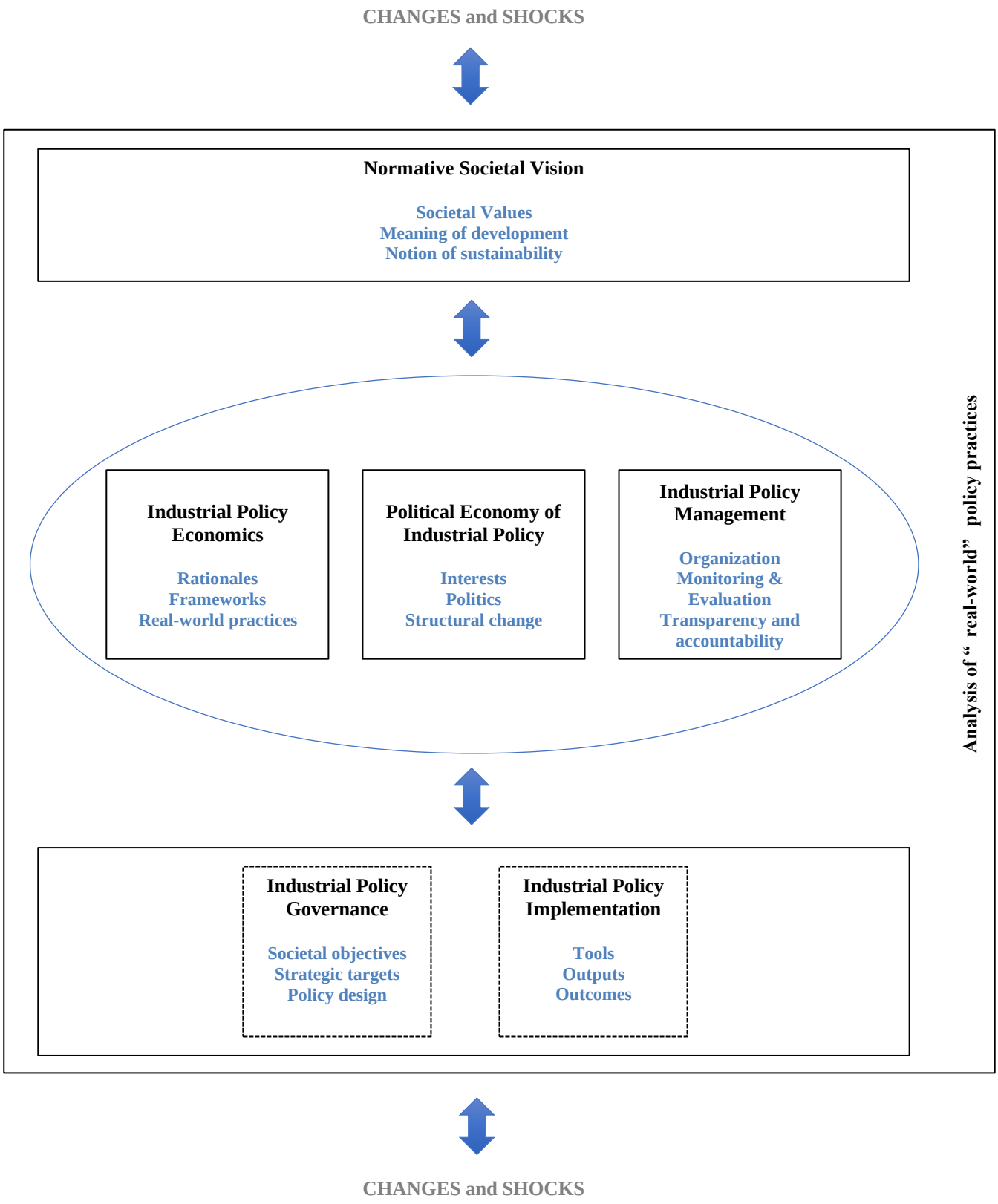
[28] Here, we draw from implementation theory (Pressman & Wildavsky, 1984; Hill & Hupe, 2002) to complement our discussion and move towards implications for public management of industrial policy.

Therefore, attention should be paid in each context by analysing the specific structural, organisational, institutional and political economy features of production systems (including their functioning and evolution); the interdependencies between industrial sectors and filiéres, as a proxy for the interdependencies of interest groups; and how multiple interests, conflicts and powers shape the political economy dynamics leading to multiple possible realizations of systemic interest.[29]

As highlighted in Fig. 2, industrial policy governance and implementation must be at the centre of a policy framework shaped both by a normative societal vision and a new understanding of industrial policy economics, political economy, and management as derived from their respective disciplines, as well as by shocks and changes emerged within and outside each economic and social system.

[29] This contributes overcoming also the limited integration of economics and politics within the developmental state literature, which made it remarkably and paradoxically static as a portfolio of economic policies or as a political structure (Fine, 2007).

Figure 2. Industrial policy-making in the post-Covid19 era



Source: Authors

Therefore, keeping into account the pillars and components of our framework, some implications for industrial policy governance and implementation can be derived.

6.1. Co-determination of societal vision and objectives

The primary implication is the co-determination of a normative societal vision and its related objectives for industrial policy. Indeed, the discussion of societal objectives and the identification of strategic priorities in our economies and societies consistent with such normative vision requires concrete mechanisms for participatory governance and collective appraisal, involving a wide set of actors within our societies. This appears coherent with the modern shift from 'government' to 'governance' underlying any policy process (Hill & Hupe, 2002) that has overcome simplistic hierarchical models. Furthermore, it embraces the recent understanding of industrial policy as a design process (Aiginger & Rodrik, 2020; Rodrik, 2004), based on an intensive dialogue and coordination between different stakeholders (such as government, industrial and trade-union interests, social actors), which highlight the respective opportunities and constraints, opening to new solutions, experiments, and collective learning.

Any country (or region) wishing to design industrial policy for sustainable human development must then foresee specific mechanisms devoted to discussing with key actors the societal priority challenges to be addressed and goals to be achieved. Whatever the mechanisms, what is crucial is that different stakeholders are called to contribute to this vision-building process to pull a systemic industrial policy (Aiginger, 2014) and coalition-building approach to ensure a broad mobilization (Rodrik & Sabel, 2019), including the academia, think-tanks, workers' and business' representatives, civil society organizations, and so forth. By managing power struggles and conflicts that may emerge in a participatory formulation of industrial policy vision and objectives, it is possible to limit regulatory capture, as well as information asymmetries, which may seriously hamper government's effectiveness in driving sustainable structural change.

6.2. Institutional arrangements for civic engagement and voicing capacity

As stressed by the political economy of industrial policy, enabling these processes and mechanisms for the discussion of societal objectives and priorities implies investing in civic engagement and voicing capacity by all social and economic groups and stakeholders, representing different interests. Indeed, certain social groups potentially carry interests on industrial policy but do not necessarily organise themselves to influence policy-making processes (Cardinale, 2018). Moreover, certain aggregations (e.g. industries, sectors, territories) may not recognise the strict system of interdependencies that tie them to each other.

Therefore, it is necessary to put in place institutional mechanisms to enable aggregations, social groups and stakeholders organizing themselves in expressing their interests and realizing to be part of a community of actors, whose partial interests should be recomposed to let emerge both a systemic interest – i.e. for the sustainability of the system itself – and a collective interest – i.e. towards a shared normative vision. According to the cultural and political specificity of each national and local setting, these arrangements may include, among others: ensuring the right to information and freedom of information to all citizens and social groups; nurturing civic engagement and critical thinking since childhood through school education; setting formal norms and requirements on participatory processes underlying industrial policy design; ensuring multi-stakeholder

processes to systematically bring together a varied set of civil society, private sector and government actors in different working groups to advise policymakers on industrial policy; recognising the role of media as a trusted and legitimate voice and accountability actor; taking advantage of new forms of civic engagement through virtual and digital tools, especially for younger generations; devoting incentives for participation in community-based organisations and civic committees; conducting action-research processes to identify voice gaps and nurture civic engagement of excluded social groups; devoting appropriate human resources to act as animators at sector or community level to bridge between public sector organisations (in terms of policymaking processes and service delivery) and sector / community needs and proposals for policy intervention.

As long emphasised in the debate, such institutional mechanisms require achieving a balance between coordination and capture through the principle of 'embedded autonomy' (Evans, 1995), for the government to be autonomous and embedded in societal networks (in particular industry and business networks) in implementing industrial policy in practice, in order to avoid one of the main sources of government failures.

For instance, if institutional structures hinder collective action, if learning processes constrain recursive actor rationality, and if consultative and deliberation mechanisms are not inclusive, thus the systemic capacity to design appropriate industrial policy strategies for societal goals would be significantly hampered (Biggeri, 2014). Furthermore, this could even lead to conflicting dynamics that result in further horizontal inequalities, polarization of power and social unrest for the reclaim of policy spaces. Rather, investments in expanding public deliberation, institution-building and collective learning could lower the magnitude and weight of transaction costs to construct a shared societal vision underlying industrial policy design.

6.3. Policy coherence and multi-level alignment

Policy coherence, multi-level alignment and synergic combination of top-down and bottom-up processes (Biggeri, 2014; Crescenzi & Rodríguez-Pose, 2011; Hill & Hupe, 2002) should become hallmarks of industrial policy governance and management. Indeed, the interplay of policy interventions from different levels based on multiple resources, institutions and capacities shapes both the industrial performance and production dynamics and their effects on social outcomes. Ensuring that industrial policy across levels are connected, integrated and aligned in the pursuit of coherent objectives and in the provision of public goods – including ''international public goods" such as global health, biodiversity, peace, free trade and scientific knowledge (Jayaraman and Kanbur, 1999) – is essential to avoid detrimental redundancies and overlaps of responsibilities and to exploit institutional and policy complementarities for an harmonized policy towards sustainable human development. In this regard, first it is important to identify those institutions and departments dealing with industrial policy design and implementation at all levels of government, i.e. in charge of translating the challenges and priorities into specific tools and targets for intervention; second, it is fundamental to invest in the building of a continuous flow of information, as transparent as possible, within the administration and across such departments; third, those involved in the making of industrial policy must have clearly in mind the normative societal vision that industrial policy is trying to achieve, and understand how this is coherently translated into targets and tools, thus limiting self-seeking behaviours by public officials.

6.4. Government capacity and complexity

Industrial policy governance and implementation need capable governments. A turning point in industrial policy must necessarily start from the idea that governments are not destined to fail and that investing in governments' capabilities must go hand in hand with the use of industrial policy. This appears fundamental to make both policy-makers (leading industrial policy governance) and public officials (leading industrial policy management) able to: embrace the complexity affecting the reality of production dynamics and societal challenges; deploy robust and evidence-based processes for the selection of strategic targets and appropriate tools; coordinate efforts and timely react to changing societal conditions and challenges; learn consciously from successes and failures of different interventions and tools. This would require both governments with pre-existing weak or strong capacities to, respectively, setting or adapting the proper governance and implementation structures for industrial policy towards sustainable human development. In this respect the international community can play a role, particularly via international organizations and academic networks that can envisage new roles in promoting exchanges of ideas, governance structures and policy practices, peer-to-peer learning among public officials, and technical assistance initiatives. This would enable multi-directional learning in designing and implementing industrial policy in all countries towards a global paradigm for a more sustainable and equitable world.

6*.5. Monitoring and evaluation*

New monitoring and evaluation frameworks for industrial policy should be designed and applied in order to recognize errors and revise policies accordingly, enhancing the relation between societal objectives and the effectiveness of interventions, for the sake of transparency and accountability toward the public interest (Rodrik, 2014). In particular, industrial policy outcomes – i.e. the real results, whether intended or unintended, that are actually achieved (Lane & Ersson, 2000) – should be evaluated against sustainable human development indicators.[30] This means accompanying traditional assessment of industrial policy – e.g. in terms of industrial or manufacturing value added (per worker/capita or as a proportion of GDP) and in terms of job creation – with indicators focusing on: small-scale industries, e.g. in terms of their value added and/or their access to loan or credit lines; medium and high-tech industries, e.g. in terms of their value added and jobs; R&I for sustainable development, e.g. in terms of researchers, expenditures and patents by SDGs; green indicators, e.g. in terms of production-based emissions (per capita or per unit of manufacturing value added), energy-related emissions and share of renewable energy in production processes; social inclusion indicators, e.g. in terms of NEET (youth not in employment, education and training); decent work indicators, e.g. in terms of adequate earnings and productive work; decent hours; stability and security of work, work-life balance; corporate organization indicators, e.g. in terms of corporate welfare and Corporate Social Responsibility; social progress and inequality, e.g. in terms of basic human needs, foundations of well-being and opportunities (as in the Social Progress Index) and in terms of societal loss in well-being due to inequality (as in the Inequality-Adjusted Human Development

[30] See Biggeri et al. (2019) and Biggeri and Ferrannini (2020) for a review of sustainable development indicators and datasets.

Index).[31] Moreover, the current debate on strategic sectors (Di Tommaso et al., 2017 and 2020a) may be complemented by accounting for Sustainable Human Development dimensions.

Thus, assessing the performances of production and industrial systems at national and subnational level should be based on new definitions of competitiveness, productivity and prosperity aligned with concerns for human development, social cohesion and sustainability (Aiginger, 2014). Similar efforts for accountability would serve to prevent corruption, favouritism and other forms of collusive behaviour, and also to legitimize appropriate industrial policies (Rodrik, 2014) pursuing a normative societal vision.

In a nutshell, these preliminary policy implications – though singularly not new in the debate – together remark the need to invest in the accurate and transparent design of industrial policy in the post-Covid19 era. They imply to establish skills, resources, capabilities and structures in public organizations to be effective at planning and learning in partnerships with the private sector and civil society, as well as at deploying and strategically coordinating multiple policy instruments and institutions addressing complex interdependencies (Andreoni & Chang, 2018).

7. Final remarks

In our post-Covid 19 economies and societies, both in developed and developing countries, a turning point on the connection between industrial policy, sustainability and development has been reached.

On the one side, well before this pandemic industrial policy was back on the agenda, starting to be conceived through a systemic approach that extends far beyond the correction of market failures and steered by societal goals for the sake of long-run collective interest. On the other side, the pandemic has surely accelerated this shift in the academic and policy-making spheres on industrial policy, revamping attention on the need for public action and government intervention on production dynamics both to tackle dramatic economic and social problems in the short run and to steer the structural transformation of the economy and the society in the medium and long run.

Nevertheless, human development, social cohesion and sustainability do not seem to have been placed at the very centre of industrial policy yet, whose urgency is apparent in the post-Covid19 era. Therefore, we argue it is time for a decisive turning point to fully reflect an integrated notion of sustainable human development (i.e. combining environmental concerns and awareness on planetary limits to growth with both people's inclusiveness, equality of opportunities and wellbeing, and with shared and long-term societal prosperity), both in the academic debate and in the real-world practices of industrial policy.

Such turning point urges us to rethinking both the theoretical foundations, as well as governance and implementation processes of industrial policy.

In this paper, we have argued that industrial policy should be conceived both as a technical and political intervention to re-design our future societies, favouring and governing a structural transformation of the industry, the economy and the whole society. This implies primarily that industrial policy must be fundamentally

[31] For instance, in 2014-2015 a sustainability-adjusted Global Competitiveness Index was computed by the World Economic Forum to assess countries for their ability to generate this long-lasting prosperity for their citizens in a socially and environmentally sustainable way.

tied to a value-based societal vision able to reconcile sustainability and development. Consequently, it implies a new understanding of the multiple inter-linkages and feedbacks among industrial policy economics, political economy and management, shaping its governance mechanisms and implementation processes.

Our analytical framework opens up a partially unexplored line of research, which requires a mutual engagement between theory and practice of industrial policy, keeping them tied to each other according to real-world conditions. Future research on industrial policy, sustainability and development would be required to explore the connection between societal goals, strategic targets and effective tools; conduct comparative analysis of industrial policy for sustainable human development in a long run perspective; analyse multi-level governance mechanisms and policy coherence; dig deeper into policy-making mechanisms and institutional settings favouring the identification of a normative societal vision and a collective interest on societal objectives, as well as conflict management, transparency and accountability; assess the effect of different industrial policy tools on wider societal goals and challenges.

In order to implement this turning point on industrial policy for sustainable human development, it is responsibility of scholars actively supporting – and engaging with – policymakers in setting industrial policies based on comprehensive, multi-level analytical principles, and carried out through robust and transparent decision-making processes. This represents an element of highest concern in a world looking (and needing) for new theoretical bases to design and implement appropriate multilevel responses in the post-Covid19 era at all levels.

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PAPER 2: TRACKING THE SDGS IN AN 'INTEGRATED' MANNER: A PROPOSAL FOR A NEW INDEX TO CAPTURE SYNERGIES AND TRADE-OFFS BETWEEN AND WITHIN GOALS

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Abstract

Monitoring the Sustainable Development Goals (SDGs) is an important challenge and strategic opportunity for stakeholders and beneficiaries involved with Agenda 2030 at all levels. To monitor progress across a diverse set of goals with multiple targets and indicators and to track overall progress, Jeffrey Sachs and associates have developed the SDG Index. Although their index is robust and permits comparisons across countries, it neglects the 'balanced' and 'integrated' nature of the SDGs, and exhibits well-known problems associated with the use of an arithmetic mean (which assumes perfect substitution between dimensions). To overcome these difficulties, this paper introduces an adjusted 'Integrated Sustainable Development Index' (I-SDI) that can take account of trade-offs and synergies between goals and targets as well as across the economic, social and environmental spheres of sustainable development. This is accomplished by introducing a new aggregation method based on the Multidimensional Synthesis of Indicators (MSI) approach. This approach overcomes well-known problems associated with replacing the arithmetic mean with the geometric mean (a difficulty encountered by the post-2010 HDI). Specifically, it makes an allowance for the heterogeneity of dimensions, while avoiding the tendency of the geometric mean to collapse to zero. In this paper, the I-SDI scores and rankings are compared with those generated by the SDG Index and the geometric mean. Moreover, to capture the heterogeneity within goals, the I-SDI2 is introduced (which applies the MSI method within as well as between goals). By taking account of heterogeneity within and between goals as well as across the economic, social and environmental dimensions of sustainable development, and by capturing synergies and trade-offs among indicators, our study reveals crucial differences in I-SDI scores and rankings that illustrate the value of a more flexible and integrated measure for guiding policymakers and monitor overall progress.

Keywords

Sustainable Development Goals; Agenda 2030; Composite index; Aggregation method; Sustainable Development Index; Multidimensional Synthesis of Indicators

1. Introduction

The end of the last century marked a turning point for the international development movement. In practice, this turning point was more of a cumulative shift that gradually picked up momentum during the 1980s and 1990s. The roots of this historic shift can be traced back at least as far as the release of the original Band Aid single ('Do they Know it's Christmas?') in 1984, which instantly became a global phenomenon. Among other things, this shift involved changes in values, attitudes and norms bolstered by heightened awareness of extreme forms of poverty (including hunger and starvation) and blatant forms of inequality and unfairness (including gender-based discrimination and human rights violations). It also involved renewed commitment and cooperation for international development at the local, national and global levels on a previously unprecedented scale. Many OECD countries began to take their longstanding commitment to spend 0.7 percent of GDP on overseas aid more seriously with real aid flows increasing from an average of $67 billion per annum in the 1980s to $73 billion in the 1990s and $97 billion in the 2000s (even if most donors continued to miss official aid targets by a wide margin).[1] Meanwhile, NGOs, civil society, private philanthropists and big business became increasingly important stakeholders, donors, and partners in development projects.

Around the same time concern for environmental sustainability increasingly crept onto the international agenda with the introduction of the first United Nations sanctioned Earth Day to promote awareness of environmental issues on 22 April 1970. Paul Ehrlich's 1968 book, The Population Bomb, and the Club of Rome's oft-cited report, The Limits to Growth (Meadows, Meadows, Randers, & Behrens, 1972), began to draw public attention to environmental concerns. But it was the publication of Our Common Future, in 1987, by the World Commission on the Environment and Development (better known as the 'Brundtland' report after the Commission's chair), that put the concept of 'sustainable development' on the international agenda and effectively mainstreamed environmental concerns (WCED, 1987). This report recognized that while growth increases material prosperity and living standards, environmental limits to growth exist in developed and developing countries alike. Awareness of these limits spurred a variety of seminal contributions on sustainable development (Tisdell, 1988; Lélé, 1991; Beckerman, 1992; World Bank, 1992; Anand & Sen, 2000) and went on to define subsequent work on environmental conservation and planetary boundaries (e.g. Goldin, 2014; Rockström & Klum, 2015; Newsham & Bhagwat, 2016).

The new momentum for international development initially found expression in the 1990 World Development Report which introduced an international poverty line based on 'a dollar a day' that strikingly identified just over a billion people globally – a fifth of the world's population at the time – as living in extreme poverty (World Bank, 1990). In the same year, the United Nations launched the Human Development Reports, which actively sought to embrace other (non-income) dimensions of development (UNDP, 1990). At the heart of these annual reports is the Human Development Index which includes indicators relating to health and education as well as income in

[1] Authors' calculation based on total average annual ODA flows in constant US dollars from DAC countries for the period 1980–89, 1990–99 and 2000–2009. The source data is taken from OECD Stat, https://stats.oecd.org/ (accessed 19 April 2019). The corresponding figure for 2010–2018 is $131 billion. Although ODA flows have increased, only a small number of Scandinavian countries (plus the UK from 2012) have met the 0.7 percent of GDP target. Since the turn of the century ODA flows from DAC countries have averaged less than 0.3% of gross income. MacFeely (2019) estimates that the cumulative shortfall in ODA between 2002 and 2016 stands at around $2.9 trillion in constant 2016 dollars.

a single composite measure that can be conveniently used to rank countries (Haq, 1995; Klugman, Rodríguez, & Choi, 2011). Outside the realm of ideas, the new movement for international development found expression in a series of United Nations conferences convened in the 1980s and 1990s that dealt with children, gender, the environment and food, among other development topics (Emmerij et al., 2001; Hulme, 2009; Kanbur, Patel, & Stiglitz, 2015).

The defining moment in the historic transformation of the international development movement, however, came with the advent of the Millennium Development Goals (MDGs) in September 2000 (United Nations, 2000). The MDGs had origins in the United Nations conferences of the 1980s and 1990s, and the OECD's own efforts to agree a set of International Development Targets (Development Assistance Committee, 1996). The MDGs, however, were radically different from anything that had come before in at least two respects. First, in addition to commanding support from international agencies such as the World Bank, United Nations and OECD, they formed the basis of a historic agreement for tackling poverty that had been unanimously endorsed by all 189 United Nations member states. Second, they were far more ambitious than anything previously agreed. In fact, they constituted nothing less than 'the world's biggest promise' (Hulme, 2009) at the time consisting of 8 timebound development goals supported by 18 targets and 60 indicators (United Nations, 2008).[2] Although the MDGs could be criticized on a variety of grounds (concerning process, coverage, coherence, etc.), they played an important role in facilitating international cooperation, encouraging aid and inspiring public support as well as effectively tackling poverty (Kanbur, Patel, & Stiglitz, 2015; United Nations, 2015a; Gasper, 2018).

The 1 January 2016 marked the transition from the MDGs to the 2030 Agenda for Sustainable Development which embraced a new set of Sustainable Development Goals (SDGs) to transform the world over the next 15 years (United Nations, 2015b). Like their predecessor, the SDGs enjoyed universal support from international organizations and all 193 member states of the United Nations. But unlike the MDGs, they are intended to be 'global in nature and universally applicable' (United Nations, 2015b, p. 1) and are therefore valid for developed and developing countries alike. Moreover, in contrast to their predecessor, the SDGs were negotiated through far more inclusive and participatory processes (Fukuda-Parr, 2016; Browne, 2017; Doods, Donoghue, & Roesch, 2017; Kamau, Chasek, & O'Connor, 2018; Gasper, 2018; Clark, Biggeri, & Frediani, 2019). Nations states rather than intergovernmental agencies led the process through the creation of a representative and responsive working group; traditional power blocks at the United Nations were challenged allowing countries such as Brazil, Colombia and Kenya and the G77 nations to play pivotal roles and to resist the demands of the United States (Gasper, 2018). Moreover, while the MDGs were negotiated behind closed doors (Hulme, 2009), the SDGs were informed by 100 national dialogues, 11 thematic consultations, a dedicated website for non-governmental stakeholders, and the results of a one-world web poll (Clark et al., 2019, p. 392; Gasper, 2018). The involvement of new and diverse stakeholders inevitably led to the broadening of development priorities. Climate change, inequality, decent work, urbanization, human rights, gender equality, peace and justice, and oceans and forests were added by various interest groups. In the end, 17 goals and 169 targets were agreed (United Nations, 2015b)

[2] The core goals emphasized: (1) eradicating extreme poverty and hunger; (2) achieving universal primary education; (3) promoting gender equality and empowering women; (5) improving maternal health; (6) combating HIV/AIDS, malaria and other diseases; (7) ensuring environmental sustainability; and (8) developing a global partnership for development.

to be supported by a global indicator framework consisting of an expanding list of 232 individual indicators to date (UNSD, 2019),[3] thus displacing a strictly monetary or economic perspective on development.

The move towards a more comprehensive and inclusive framework for tackling sustainable development is an important step forward. According to the 2030 Agenda for Sustainable Development, the goals and targets incorporated in the SDGs are ''integrated and indivisible and balance the three [economic, social and environmental] dimensions of sustainable development..." (United Nations, 2015b, p. 1). At the same time, however, the dramatic increase in the number of goals, targets and indicators has invited criticism with respect to digesting, monitoring and managing such a diverse, complex and interrelated set of achievements. One response has been to focus on local and sectoral priorities to contextualize the monitoring of the SDGs. Another response has been to advocate falling back on a (relatively) small set of subgoals (see Section 2). Neither of these strategies is helpful for making international comparisons or monitoring 'global' aspects of development such as climate change or deforestation. Some recent contributions have begun to develop aggregate measures based on SDG indicators for certain sectors (e.g. Brelsford, Lobo, Hand, & Bettencourt, 2017 for the urban environment; Giupponi & Gain, 2016 for water, energy and food; Nhemachena et al., 2018 for agriculture), and specific countries or regions (e.g. Bobylev, Zubarevich, & Solovyeva, 2015 for Russia; Guijarro & Poyatos, 2018 for the EU28 countries).

Many observers have pointed out that the SDGs are significantly broader and far more ambitious than the MDGs. For these reasons some commentators have pointed to ''the importance of creating an effective performance measurement system for the 2030 development agenda" (Jacob, 2017, p. 235) or have argued that ''The SDGs need an overarching goal with clear metrics of progress toward that goal that are geared to integrate the sub-goals" (Costanza et al., 2016, p. 350).

To date only one contribution attempts to develop and apply a single unified indicator for monitoring progress towards the SDGs at the global level.[4] The indicator in question, the Sustainable Development Goal Index (SDG-I), has been developed by Jeffrey Sachs et al. (2016, 2017, 2018) on behalf of Bertelsmann Stiftung and the Sustainable Development Solutions Network (SDSN). It draws on available data from a variety of publicly available sources for all 193-member states of the United Nations from the year 2016 onwards. The SDG-I is derived from a scoring system that uses the arithmetic mean to aggregate indicators relating to each of the 17 SDGs in turn, before 'averaging' the results into a single metric. A system of equal weights is deliberately employed to reflect international commitments ''to treat each SDG equally and as an integrated and indivisible set of goals" (Sachs et al., 2018, p. 41). Although the SDG-I is not intended to replace the global dashboard of indicators for monitoring the SDGs (Sachs, Schmidt-Traub, Kroll, DurandDelacre, & Teksoz, 2017, p. 32), it does have huge potential (like other well-known composite indicators) for identifying priority areas for action, tracking overall progress, and making international comparisons.

A variety of issues are involved in constructing composite indicators to guide development practice (Saltelli, 2007). One well-known problem relates to relying on an index based on the arithmetic mean – particularly if we are concerned with the integration of interconnected indicators and targets. This is because the arithmetic mean

[3] See also the Sustainable Development Goals Knowledge Platform, https://sustainabledevelopment.un.org/.

[4] Costanza et al. (2016) also proposes a Sustainable Well-Being Index to complement the SDGs along with a dynamic model that can be used to take account of stocks and flows and make predictions. They have not yet made their index or proposed model operational, although their approach has the potential to address interconnections between the SDGs.

effectively assumes that different targets and indicators are perfects substitutes for each other; no account is taken of positive synergies (that reinforce development processes) or negative externalities (that undermine other aspects of development). One alternative sometimes suggested in the literature is to use the geometric mean instead; this approach limits substitution between heterogeneous dimensions, but has the unfortunate drawback of collapsing towards zero in cases where an indicator for any of the constituent components approaches or reaches zero (see Section 2.3).

Mauro, Biggeri, and Maggino (2018) have recently developed a new aggregation method – known as the Multidimensional Synthesis of Indicators (MSI) approach – that is simultaneously able to overcome the theoretical problems associated with the use of the arithmetic mean or the geometric mean in composite indices. This paper uses the MSI approach to develop and explore an adjusted-SDG Index (dubbed the 'Integrated Sustainable Development Index' or 'I-SDI') that is better placed to capture the linkages and interconnections between different components of the SDGs.

The discussion is organized as follows. Section 2 considers the case for a metric that can better capture the full complexity and integrated nature of the 2030 Agenda for Sustainable Development. Section 3 briefly describes the available datasets for tracking the SDGs. Section 4 presents a new method for constructing an Integrated Sustainable Development Index (I-SDI and I-SDI2) based on the MSI method. Section 5 presents and discusses the results – new index estimates and country rankings – and their implications, and Section 6 concludes.

2. Conceptualising and measuring sustainable development in an integrated way

2.1. The complex, indivisible and interconnected nature of the 2030 agenda for sustainable development

From inception the post-2015 agenda for sustainable development ''embrace[d] the so-called triple bottom line approach to human wellbeing" (Sachs, 2012, p. 2206), combining economic development, environmental sustainability, and social inclusion. The balance among the three dimensions of sustainable development – the economic, social and environmental – is one of the hallmarks of the Sustainable Development Agenda, strongly supported by research [5] and a broad consensus (Sachs, 2012). This paved the way for the Sustainable Development Goals and targets to be ''integrated and indivisible, global in nature and universally applicable" (United Nations, 2015b, p. 13), helping overcome some of the drawbacks of the MDGs that were ''a North-South aid agenda" based on a ''narrow conception of development" (Fukuda-Parr, 2016, pp. 44– 45).

The integrated and indivisible nature of Agenda 2030 reflects the deep interconnections and cross-cutting elements across the goals and targets, making inter-linkages crucial in ensuring that sustainable development is pursued. Together the SDGs provide a set of global priorities (with universal validity) that are fundamentally interdependent, calling for an understanding of interactions between goals along with coherence in design, implementation and monitoring. Moreover, notions of 'indivisibility' and 'integration' call for improved governance (Hulme, Savoia, & Sen, 2015; Joshi, Barry, & Sisk, 2015; Kanie & Biermann, 2017) and for multi-level implementation and multi-actor responsibility in the pursuit of the SDGs (UNDG, 2014; Koehler, 2015; United

[5] See Sachs (2012) and Griggs et al. (2014), among others.

Nations, 2015b; Smoke & Nixon, 2016; Gupta & Nilsson, 2017; GTF, 2016; Horn & Grugel, 2018; Clark et al., 2019), linking global, regional, national and local levels, public, private and social actors, and cutting across national borders in terms of effort, regulation and effects – especially concerning environmental issues (e.g. climate change, ecosystems protection), peace and security (e.g. conflict prevention and resolution, peacekeeping and peace-building) and trade (e.g. standards, quotas and tariffs).

It follows that measuring and monitoring SDG achievements should reflect the integrated nature of goals and targets, primarily in terms of inter-linkages as well as in terms of complementarities across levels of implementation, from both theoretical and practical perspectives. It is critical to understand what the areas of synergies and trade-offs among goals and targets might be, and how and to what extent realising – or failing to realise – one particular achievement may impact positively or negatively on other goals and targets.

In recent years an increasing number of policy-orientated contribution are assessing potential synergies (Table 1) and possible trade-offs (Table 2) between the goals and targets associated with the SDGs.[6]

These contributions illustrate the scale and nature of the complexities involved in integrating individual SDGs and their targets.[7] Trade-offs between goals and targets have become sharper following expansion from the MDGs to the SDGs (Kanbur, Patel, & Stiglitz, 2015). In addition, the move towards an integrated system of SDGs reflects ''recognition by the international community of the importance of links among the goals" (Le Blanc, 2015, p. 15), and raises the prospect of designing complementary strategies across sectors. In this respect, unlocking the full potential of the 2030 Agenda for economic, social and environmental development will involve identifying and leveraging positive synergies through mutually reinforcing policy actions along with rendering trade-offs ''structurally non-obstructive" (Pradhan, Costa, Rybski, Lucht, & Kropp, 2017, p. 1) as far as possible to ensure that progress in some goals and targets is not achieved at the expense of others.[8] It is also vital to understand whether, and if so how and to what extent, countries differ in their capacity to capitalize on synergies and positive inter-linkages across goals and targets. In other words, tracking the SDGs needs to ''chart out integrated pathways for achieving the goals" (Schmidt-Traub, Kroll, Teksoz, Durand-Delacre, & Sachs, 2017, p. 547), highlighting positive or negative examples.

In sum, the indivisible and integrated nature of the SDGs and their targets – along with their universality – makes the 2030 Agenda for Sustainable Development much more complex than its antecedent in terms of implementation and measurement.

[6] The studies considered in these tables are not intended to represent an exhaustive review of the available literature. For a parallel literature on the interconnections between different aspects of human development see Ranis, Stewart, and Ramirez (2000), Mehrotra and Delamonica (2007) and the contributions discussed in Section 2.2.

[7] One graphic illustration is provided by the Institute for Global Environmental Strategies 'Interlinkages Analysis & Visualisation Tool (v2.0)' (https://sdginterlinkages.iges.jp/) which shows how separate and diverse elements of the SDGs interact with each other depending on the type of linkage and spread of indicators selected. Although this is a promising tool for informing policy discussions at the local and national level, it is only available for a selection of nine Asian countries including China.

[8] So far trade-offs among SDGs have been mostly modelled as negative correlations, and we follow this line of reasoning. In the future, research utilising time series data covering longer time spans will permit superior analyses of sustained inverse relations among SDGs over time.

Table 1. Observed synergies between the SDGs.

Authors	Area	Findings
Barbier and Burgess (2017)	Global	Reducing poverty (SDG1) can be further boosted by positive gains from improvements in Clean Water and Sanitation (SDG6) and Zero Hunger (SDG2)
Fuso-Nerini et al. (2017)	Global	Identifies 113 targets that require action to enhance energy systems and evidence of a link between 143 targets and 'access to affordable, reliable, sustainable and modern energy' (SDG7)
ICSU (2017)	Global	Presents a detailed analysis of target level interactions for four SDGs and finds evidence of 50 positive interactions for SDG2 (Zero hunger), 81 positive interactions for SDG3 (Good health and well-being), 46 positive interactions for SDG7 (Affordable and clean energy) and 61 positive interactions for SDG14 (Life below water)
Le Blanc (2015)	Global	Stresses that 'the inclusion of standalone goals on sustainable consumption and production patterns [SDG12] and inequality [SDG10] ... make the SDGs more tightly knit as a network...' (Le Blanc, 2015, p. 15)
Mainali et al. (2018)	Six countries in South Asia and sub-Saharan Africa	Network analysis points to 'three reinforcing linkages and one dependent linkage among the targets associated with poverty alleviation (SDG1) and energy access (SDG7), nine reinforcing linkages among the targets associated with poverty alleviation (SDG1) and sustainable agriculture (SDG2), and six reinforcing linkages between poverty alleviation (SDG1) and clean water and sanitation access (SDG6). Similarly, four dependent linkages between SDG7 and SDG2 and three dependent linkages were observed between SDG7 and SDG6' (Mainali et al. 2018, p. 19)
Nilsson et al. (2016)	Sub-Saharan Africa	Ending hunger (SDG2) interacts positively with poverty eradication (SDG1), health promotion (SDG3) and quality education for all (SDG4)
Pradhan et al. (2017)	Global	Poverty elimination (SDG1) has a synergetic relationship with most of the other goals; and health and well-being (SDG3) has synergies with other SDGs in most countries and across most population groups
Singh et al. (2018)	Global	Focuses on how SDG14 (Life below water) contributes to other goals. Target 7 (to increase economic benefits to small island developing states and least developed countries from the sustainable use of marine resources) is positively related to all other SDGs; target 4 (involving the elimination of overfishing, illegal and destructive fishing practices) is a necessary precondition for achieving the largest number of other SDG targets; eliminating poverty (SDG1) and ending hunger (SDG2) are highly dependent on ocean sustainability

Source: Authors

Table 2. Observed trade-offs between the SDGs.

Authors	*Area*	*Findings*
Barbier and Burgess (2017)	Global	Reducing poverty (SDG1) and hunger (SDG2) as well as improving access to clean water and sanitation (SDG6) between 2000 and 2015 may have come at the expense of other environmental and social SDGs, making our economies less sustainable
Fuso-Nerini et al. (2017)	Global	'[T]rade-offs relate to tension between the need for rapid action to address key issues for human well-being (for example, poverty eradication, access to clean water, food and modern energy, and so on), and the careful planning needed to achieve efficient energy systems with a high integration of renewable energy.' (Fuso-Nerini et al., 2017, p. 11)
ICSU (2017)	Global	The analysis identifies a set of potential constraints and conditionalities among targets in SDG2, SDG3, SDG7 and SDG14 that require coordinated policy interventions to protect the vulnerable, ensure equity and manage competing demands over natural resources to support sustainable development
Nilsson et al. (2016)	Sub-Saharan Africa	In some parts of sub-Saharan Africa promoting food production (SDG2, target 4) can constrain renewable energy production (SDG7) and terrestrial ecosystem protection (SDG15)
ODI (2017)	Southern Africa	There may be potential conflicts between (a) protecting forests (SDG15.2) and food/nutrition security (SDG2.3); (b) inclusive and sustainable industrialization (SDG9.2) and its ecological sustainability (SDG9.4); and (c) economic growth (SDG8.1) and income inequality (SDG10.1)
Pradhan et al. (2017)	Global	SDG12 'Responsible consumption and production' is the goal most commonly associated with trade-offs
Scherer et al., 2018	Global	Imposing a minimum per capita income level of $1.25 per day for the extremely poor (SDG1) limits environmental impacts in SDG6, SDG13 and SDG15. Reducing intra-national inequality (SDG10) by limiting the Gini index of income to a maximum of 0.3 produces significantly heterogeneous results on environmental targets
Singh et al. (2018)	Global	Ending overfishing (SDG14.4) and harmful fishing subsidies (SDG14.6) can contribute negatively to targets related to youth employment (SDG8.6). And protecting marine areas can exclude access to coastal resources and restrict progress towards ending hunger (SDG2) and curbing disparities that affect poor people (SDG10)
von Stechow et al. (2016)	Global	Some 2°C pathways (SDG13) could, if not designed properly, undermine sustainable development in non-climate dimensions

Source: Authors

2.2. Arguments for an integrated approach to development

There is a strong conceptual and practical case for embracing the complex nature of development in an integrated and systematic way more generally. Over the years, different contributions to the literature have emphasised the importance of distinguishing between inputs and outputs of development processes (Torlockyj, 1975; Hicks & Streeten, 1979), the means and ends of development (Streeten, 1994; Haq, 1995), and the many complex linkages and interactions between different capabilities and freedoms (Sen, 1999; Clark, 2002, 2005, 2017; Biggeri & Ferrannini, 2014).

The methodological case for embracing complexity – instead of sweeping it under the carpet – has been forcefully made by Amartya Sen (1989) with respect to economic and social theory.[9] His basic argument applies to a variety of social phenomena including 'poverty' and 'development':

> ... if an underlying idea has an essential ambiguity a precise formulation of that idea must try to capture that ambiguity rather than attempt to lose it. Even when precisely capturing an ambiguity proves to be a difficult exercise, that is not an argument for forgetting the complex nature of the concept and seeking to spuriously narrow exactness. In social investigation and measurement, it is undoubtedly more important to be vaguely right than precisely wrong (Sen, 1990, p. 45).

Recently, the philosophical case for a more unified and integrated approach for thinking about sustainable development has been articulated by Mozaffar Qizilbash. In his keynote address to the Cambridge Capability Conference in June 2018, he begins by distinguishing between 'inclusionary' and 'exclusionary' views of development, before showing that rival approaches to sustainable development can be reconciled in a variety of ways (Qizilbash, 2018). Although his substantive contribution is to show that apparent differences between the human development approach and the capability approach can – to a large extent – be squared if the latter is interpreted in an inclusionary manner, his paper also demonstrates that other approaches to sustainable development including economic growth, environmental sustainability, and utilitarian notions of welfare also have inclusionary elements that can be used to build consensus among competing paradigms. For example, Qizilbash observes that even the most exclusive form of utilitarianism (the 'happiness' view), can indirectly endorse the four pillars of human development identified by Mahbub ul Haq – equity, sustainability, productivity and empowerment (Haq, 1995) as well as four similar pillars of sustainable development identified in The World Happiness Report 2012 that are said to be entrenched in the SDGs – ending poverty, environmental sustainability, social inclusion and good governance (Helliwell, Layard, & Sachs, 2012).

The 2030 Agenda for Sustainable Development comes close to representing a single unified framework (with international validity) that can appeal to different viewpoints and schools of thought. Of course, it is still possible to challenge the content, structure and coherence of the SDGs. Some critics have argued that the new consensus does not go far enough because it does not cover key issues that are likely to concern the world in coming decades such as migration, terrorism, capital flight and democracy (see Gasper, 2018). Others have pointed out that vital indicators for specific targets and goals are missing including total carbon emissions, the share of

[9] For a discussion with respect to conceptualising and measuring poverty see Lemmi and Betti (2006), and Clark and Qizilbash (2008).

woman in non-agricultural employment and various indicators relating to trade, aid and debt. In terms of coherence, Vandemoortele (2017) ''warns that only 30 of the 169 ''targets" formulated in [the SDGs] are clear, time specific and quantified" (Gasper, 2018, p. 16); while officially, as things currently stand, less than half of all indicators for monitoring the SDGs are classified as tier 1, i.e. conceptually clear with a standard methodology and available data for all regions (IAEG-SDGs, 2019). Meanwhile, Kanbur, Patel, and Stiglitz (2015) show that the SDGs – like the MDGs – continue to mix up inputs, outputs and outcomes.

Some disingenuous critics point to the case for scaling down the SDGs by claiming that they are ''senseless, dreamy and garbled" (Easterly, 2015); or by suggesting that ''something for everyone has produced too much for anyone" (Economist, 2015). The SDGs, however, should not be judged purely in terms of conceptual or technical precision. Collectively, they represent a roadmap for a better future that inspires action and cooperation among diverse multilevel actors and agents of change. Moreover, the argument that 17 goals and 169 targets are too much depends on context and the purpose of the exercise. In this respect, Kanbur, Patel, and Stiglitz (2015, p. 14) have argued that the SDGs are ''a useful platform from which to choose and narrow down" a set of indicators. They suggest that there is a strong case for keeping the number of indicators on dashboards to well under ten (p. 8). In the case of South Africa and other African countries, they expect top-level indicators to include per capita income, income inequality and poverty, employment, a multidimensional deprivation index based on access to basic public services, and long-term environmental degradation (p. 9). Such dashboard can sharpen priorities, simplify and reduce costs, and spur partnerships for development.

But even streamlined dashboards are not the best tools for all jobs. A notable advantage of a single aggregate measure (such as the SDG index) is that it provides a straightforward and easy-to-interpret summary of overall performance that might be difficult to discern from analysing multiple targets and indicators that often overlap and move in different directions (Clark, Fennell, & Hulme, 2017; Schmidt-Traub et al., 2017). In other words, ''having a wellinstrumented dashboard in your car is essential, but so is knowing where you are going and whether you are making progress toward your destination" (Costanza et al., 2016, p. 351). Moreover, they may be ''more effective in stimulating public debates than a large number of individual scores which could result in cherry picking" (Schmidt-Traub et al., 2017, p. 548). Another advantage is that an aggregate measure facilitates tracking progress over time, as well as easy comparisons across countries for ranking and benchmarking relative performances in given areas, as means not only of stimulating public awareness and discussion (OECD, 2008), but also of increasing accountability and transparency, and boosting further analysis (Freudenberg, 2003) to aid the design of better policies.

For these reasons, composite measures have considerable analytical power as well as enormous political clout, as their frequent use by international organisations (Bandura, 2011; OECD, 2008; Yang, 2014) and scholars from across the social sciences shows (Booysen, 2003; Cherchye, Moesen, Rogge, & Van Puyenbroeck, 2007; Michener, 2015; Sundström, Paxton, Wang, & Lindberg, 2017; Greco, Ishizaka, Tasiou, & Torrisi, 2019). It follows that the pragmatic value of composite indicators such as the UNDP's Human Development Index, the World Bank's Ease of Doing Business Index, the OECD's Better Life Index, and the World Economic Forum's Global Competitiveness Index is reflected in their capacity to shape policy debates and prevailing political discourses (Paruolo et al., 2013) by simplifying and effectively communicating complex multi-dimensional concepts and issues that facilitate the 'generation of narratives supporting the subject of the advocacy' (Saltelli, 2007, p. 68).

The Human Development Index is perhaps the most obvious and well-known example. This 'eye-catching' statistic has captured the imagination of politicians and the press, guiding governments' planning, policy and allocation processes towards multidimensional development. Moreover, it has been partially successful in threatening the hegemony of GNP in development accounting (see also Streeten, 1994; Haq, 1995; Sen, 2006), as well as in inspiring innovation and efforts in the measurement of different aspects of well-being at the local, national and regional levels (Dervis and Klugman, 2011).

There are, however, well-known difficulties with the construction and use of composite indicators for gauging social phenomena such as 'development' (Saisana & Tarantola, 2002; OECD, 2008; Stiglitz, Sen, & Fitoussi, 2009). First, their practical value comes at the expense of losing the richness of information attached to specific targets and indicators; for this reason, it is ''not credible to contend that any single index could capture all that matters in all settings" (Kanbur, Patel, & Stiglitz, 2015, p. 8). Second, the arbitrary nature of the procedures used to select, aggregate and weigh their components (among other methodological issues) raises normative issues that are typically not made explicit or justified (Stiglitz, Sen, & Fitoussi, 2009). Third, their construction and analysis are more data intensive and require greater levels of commitment and understanding than simpler individual indicators before they can enjoy widespread recognition, acceptance and support. Fourth, when poorly constructed, misinterpreted or misused there is a high risk that summary indicators can send misleading messages based on 'big picture' results that distort policy measures (Saltelli, 2007; OECD, 2008). Similar concerns have been raised with reference to the HDI which has been criticised as ''a quick and imperfect glance at human lives" (Sen, 2006, p. 257) that ''may conceal at least as much as it reveals about the nature of human well-being and development" (Clark, 2014, p. 847).

Although the debate on the relative merits of social indicators may never be settled (as Saisana, Saltelli, & Tarantola, 2005 argue), these metrics can still play a useful role in social analysis as long as their limitations are fully appreciated, and appropriate allowances are made. In terms of the 2030 Agenda for Sustainable Development, such a metric can help gauge the complex and integrated nature for the SDGs for research, advocacy and awareness raising purposes. But it is also important to remember that the SDGs can be conceived 'in a broad perspective, as a platform which provides global civil society with a base from which to organise around one of the many issues in the SDGs' (Kanbur, Patel, & Stiglitz, 2015, p. 6). Such a design requires a global indicator framework that provides multiple entry points for policymaking by providing a starting point for discussing, assessing and comparing progress and by identifying priority areas for improving performance (Nhemachena et al., 2018).

Of course, any composite measure of sustainable development, could only provide a partial and imperfect representation of a global indicator framework. Although the former provides an informative summary measure, a disaggregated set of indicators is still required to identify priorities and design a coherent set of policies to guide specific goals and targets. As Stiglitz, Sen, and Fitoussi (2009, pp. 238–239) observe:

> On the whole ... composite indicators are better regarded as invitations to look more closely at the various components that underlie them. This kind of function of composite indicators has often been put forward as one of their main raisons d'être. ... Once we have the global view, we can return to detailed elements: a country that is badly ranked can look at the variables that are predominantly

responsible for its situation and try to improve its score along these variables. Such an incentive to policy change is not to be neglected at all.

Although the SDG Index is fully aligned with these arguments there is scope for improvement. In particular, it could be modified to aggregate components in a more integrated way by drawing on the MSI methodology (see Sections 1 and 4).

2.3. The contribution of the SDG Index

As we have seen in the introduction, the SDG Index developed by Sachs and associates is the most comprehensive attempt to date to capture overall performance in sustainable development within a single composite index that can be used to make comparisons across countries and over time.

By using publicly available data for all 193 UN member states in 2016, 2017 and 2018 (see Section 4 of this paper), Sachs et al. (2016, 2017, 2018) annually calculate and release aggregate statistics to show how countries are preforming with respect to the SDGs. Four main objectives shared by many other researchers motivate their work: i) providing a useful, operational tool for policy action; ii) supporting debates on the prioritization of goals and the formulation of strategies; iii) contributing to a robust SDG monitoring framework; and iv) identifying gaps in statistical monitoring systems. Taking account of the need to balance scientific soundness with easily communicable results accessible to a wide audience, the SDG Index score is interpreted as the percentage of achievement given by the distance to invariant targets for goals. Lafortune, Fuller, Moreno, Schmidt-Traub, and Kroll (2018, p. 7) outline the methodology applied to compute the SDG Index, which can be recapped as follows: i) censoring the data at the bottom 2.5th percentile as the minimum value for the normalization of indices; ii) rescaling each variable as an ascending variable from 0 to 100 with 0 denoting the worst performance and 100 describing the best possible 'technical optimum' in terms of sustainability; iii) employing equal weights for goals to reflect the fact that each SDG is of equal importance and part of an integrated agenda; iv) aggregating the scores for each SDG into a unique index for each country through the arithmetic mean, as the authors remark on its technical appropriateness and the simplicity of its interpretation for policy makers and the general public.

Lafortune et al. (2018, pp. 23ff) briefly consider other aggregation procedures, but do not find any real advantage in using the geometric mean in place of the arithmetic mean. Instead, they praise the simplicity of the arithmetic mean and observe that a correlation coefficient of 0.977 between these two aggregation methods will produce ''very similar rankings" (p. 24). Yet they do recognise that the geometric mean has a desirable 'limited substitutability' property for aggregation across heterogeneous variables (see also Klugman et al., 2011; UNDP, 2010). However, if an outcome is zero (i.e. for the synthetic index of any of the 17 Goals), the synthesis among all SGDs through the geometric mean will collapse to zero. For this reason, the estimate of the correlation coefficient between the two aggregation measures considered by Lafortune et al. (2018) is questionable because the correlation is calculated by omitting those dimensions that score zero (although in fairness this only applies to a limited number of countries).[10] If these zeros are included, the correlation remains high but is reduced to

[10] The score in SDG1 is zero for Burundi and Central African Republic; the score in SDG7 is zero for Liberia; the score in SDG10 is zero for Botswana, Namibia, South Africa and Swaziland; and the score in SDG17 is zero for Turkmenistan.

0.816. Moreover, simply looking at this correlation coefficient can be misleading when analysing country rankings.

Despite the technical limitations of the SDG Index, the overall methodological approach is robust and Sachs's et al. work is highly relevant and useful for informing debate and guiding strategic policy-making. Yet substantial doubts remain regarding the effective capacity of the SDG Index to: i) deal with the aforementioned synergies and inter-linkages between the SDGs[11] by rewarding virtuous integrated pathways with high(er) score across the different goals, and vice-versa; and ii) systematically and effectively penalize poor performances in particular indicators that hamper the sustainability of development trajectories and potentially affect – through negative spill-overs – global pathway towards a more sustainable world. In other words, Sachs and his colleagues tackle a highly relevant issue but have not arrived at the most effective solution for measuring, tracking and comparing aggregate performance in an index representing the pursuit of an indivisible and integrated 2030 Agenda for Sustainable Development.

The Multidimensional Synthesis of Indicators (MSI) approach (Mauro et al., 2018) applied in this paper attempts to enhance the SDG Index by introducing a new method of aggregation capable of robustly taking account of the inter-linkages between the SDGs (see Section 4). In comparison to the standard SDG Index, the Integrated Sustainable Development (I-SDI) produces different scores and rankings (see Section 5). It follows that further investigation is warranted. In Paruolo, Saisana, and Saltelli (2013, p. 610) words, ''the statistical analysis of composite indicators is essential to prevent media and stakeholders from taking them at face value [...], possibly leading to questionable choices of policy."

3. Data availability and limitations

As mentioned, the 2030 Agenda for Sustainable Development is composed of 17 goals and 169 targets. Although the processes and mechanisms behind the design and implementation of the global development framework has attracted the most attention, significant discussion has also been devoted to an extensive and expanding indicator framework intended to track and monitor the SDGs. Global reasoning on the post-2015 Development Agenda was initially led by the United Nations Statistical Division in collaboration with the Statistical Office of the European Union who organised a conference in January 2015 on the 'Transformative Agenda for Official Statistics' to help design a new strategic indicator framework. In September 2015 an international mandate to strengthen global statistics followed in Transforming Our World (United Nations, 2015b, para 48, 57), and in March 2016 a set of indicators developed by the Inter-Agency Expert Group on the SDG Indicators (IAEG-SDGs) were agreed as a ''practical starting point" by the United Nations Statistical Commission (UNSC, 2017, p. 2).

Further collaboration led to the Cape Town Global Action Plan for Sustainable Development Data prepared by the High-level Group for Partnership, Coordination and Capacity-Building for statistics for the 2030 Agenda for Sustainable Development (HLG-PCCB), which was adopted by the United Nations Statistical Commission in March 2017. This plan identified six strategic areas (associated with particular objectives and key actions) for improving

[11] See, for example, the matrix of Pearson correlation coefficients across SDGs provided by Lafortune et al. (2018, p. 25).

statistical capacity: 1) Coordination and strategic leadership on data for sustainable development; 2) Innovation and modernization of national statistical systems; 3) Strengthening of basic statistical activities and programmes, with particular focus on addressing the monitoring needs of the 2030 Agenda; 4) Dissemination and use of sustainable development data; 5) Multi-stakeholder partnerships for sustainable development data; and 6) Mobilize resources and coordinate efforts for statistical capacity building (UNSC, 2017).

In July 2017, the United Nations General Assembly adopted the global indicator framework developed by the United Nations Statistical Commission and the IAEG-SDGs as ''a voluntary country-led instrument... to be refined annually" in accordance with ''the periodic review of new methodologies and data as they become available..." (United Nations, 2017b, para 1, 3).

In this regard, it is worth recalling the three-tier classification for evaluating global SDG indicators developed by IAEG-SDGs.[12] This classification is frequently updated and depends on methodological development and data availability at the international level, as follows: Tier 1 indicators are conceptually clear, have an internationally established methodology and standards, and are available for the majority of countries; Tier 2 indicators are conceptually clear, have an internationally established methodology and standards, but sufficient data for monitoring purposes is not widely produced; and Tier 3 indicators currently lack an internationally established methodology or standard, although appropriate methods or standards will be developed (IAEG-SDGs, 2019).[13]

Three main databases are currently available for monitoring the SDGs. The first of these is the official Global SDG Indicators Database maintained by UN Stats. This platform contains over one million observations (although several indicators and data points are repeated) from the year 2000,[14] thus giving the user access to the same country-level data and regional and global aggregates utilised in the Secretary-General's annual Progress Towards the Sustainable Development Goals reports (see United Nations, 2017a, 2018). In addition, the Open SDG Data Hub (2018) allows the user to explore and analyse official SDG source data to facilitate evidence-based decision-making and advocacy; and the SDG indicators Application Programming Interface (API) gives access to the Global Indicators database via OpenAPI specifications.

Since 2016 the World Bank has provided a second database through the annual release of an Atlas of Sustainable Development Goals (World Bank, 2017, 2018).[15] This Atlas complements the information provided by UN Stats by drawing on the globally renowned World Development Indicators, which includes 1600 indicators for 217 economies.[16] One advantage of the World Bank's dataset is the available time-span as many indicators can be tracked from 1960 onwards.

As mentioned, Bertelsmann Stiftung and SDSN have assembled a third dataset for monitoring the SDGs that consists of 86 global indicators (plus an additional 35 indicators for OECD member states) from a variety of official and unofficial sources that are publicly available.[17] Official data from national governments constitutes around two-thirds of their data, which helps to ensure that concepts, collection methods and results are consistent and comparable. The remaining data comes from unofficial sources collected by universities, NGOs and private sector

[12] See https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/. 13 14 15 16 17

[13] The latest available classification of indicators (as at 22 May 2019) lists 104 tier 1 indicators, 88 tier 2 indicators, and 34 tier 3 indicators. A further 6 indicators have components that are classified under multiple tiers (IAEG-SDGs, 2019, p.2).

[14] See https://unstats.un.org/sdgs/indicators/database/.

[15] See http://datatopics.worldbank.org/sdgatlas/index.html.

[16] See http://datatopics.worldbank.org/world-development-indicators/.

[17] See http://www.sdgindex.org/reports/2018/.

organisations using a variety of techniques, which can be used to bridge some of the data gaps in official sources. As noted in the 'SDG Index and Dashboards Detailed Methodological Paper', around 35 percent of these indicators match exactly those listed by IAEG-SDGs, 24 percent are closely aligned, and 40 percent are not included in the UN Stat database (Lafortune et al., 2018, p. 16).

It is beyond the scope of this paper to assess the merit of Hák, Janousˆková, and Moldan (2016) call to focus on more robust conceptual and methodological work to bolster the global indicator framework before concentrating on the production of new economic, social and environmental statistics. But it is evident that the available datasets facilitate meaningful progress by allowing decision-makers to ''discover, understand, and communicate patterns and interrelationships in the wealth of SDG data and statistics that are now available" (Open SDG Data Hub, 2018). Nevertheless, three core weaknesses in the global indicator movement should be kept in mind. First, several factors continue to constrain the availability of consistent, high quality and comparable data across countries (Vandemoortele, 2017). In some cases, indicators lack scientifically robust definitions (Schmidt-Traub et al., 2017), requiring international organisations, national and local governments, civil society and private sector organisations to develop a more effective monitoring system for sustainable development by contributing to, and investing in, the collection of more accurate, consistent and reliable data.[18] In this respect, Jacob (2017) shows that one important lesson the 2030 Agenda for Sustainable Development can learn from the MDG indicator framework, is that inefficient performance measurement can result in development failures.

Second, the limited availability of disaggregated data at subnational level hampers effective monitoring at local level, particularly in large and diverse countries such as India and China. This is a significant problem for some goals and targets – for example, SDG 10 which includes an explicit focus on within country inequality. National and supranational statistical offices are attempting to address this problem (for example, EuroStat and the OECD are connecting the SDGs with regional and local statistics), but the international community still lacks a common unified framework to compare indicators and performance across sub-national areas, which increasingly represent important spheres for analysis and the implementation of policy as the 'SDGs localisation' debate shows (UNDG, 2014; GTF, 2016). Third, the SDG Index developed by Sachs and associates represents the only substantial attempt to date to track the SDGs at the global level using a single aggregate measure, despite methodological concerns regarding composite indicators (see Section 2.2). Yet so far, little critical attention appears to have been devoted to the conceptual and methodological development of their SDG Index.[19]

This paper addresses the third limitation by demonstrating that it is possible to improve on a single aggregate measure for tracking and monitoring the SDGs at country level through the application of the MSI methodology. It is also worth noting that the MSI methodology can be expanded to sub-national accounts, helping to monitor the SDGs across localities which addresses the second criticism mentioned above.

[18] One area of expanding interest is the role 'big data' can play in monitoring the SDGs (Paul, 2018).

[19] A literature search conducted in December 2018 using Google Scholar to look for the terms 'SDG Index', 'Sustainable Development Index' and 'Sachs Sustainable Development Index' did not reveal any obvious critiques.

4. A new method for aggregating an 'integrated' SDG index

The 2030 Agenda for Sustainable Development is the latest in a long line of contributions that have questioned GNP per capita as the most appropriate yardstick for monitoring 'development' and have introduced new indicators for defining and measuring development (Seers, 1969; Hicks & Streeten, 1979; Sen, 1985; UNDP, 1990; Haq, 1995; Clark, 2002; Stiglitz, Sen, & Fitoussi, 2009).

At the same time, the deluge of new data has given rise to new challenges, both practical and theoretical, that need to be managed through appropriate methodologies. Various approaches have been used to aggregate indicators of societal well-being and progress. An important challenge relates to the aggregation and interpretation of social statistics, and, although the technical literature on composite indexes and functions has grown rapidly in recent years (see for example, Greco et al., 2019), some aspects require strengthening. One such aspect follows on from the recognition that development is multidimensional and should embrace an expanding number of core dimensions. The implication for aggregating across an expanding set of dimensions relates to the growth of complexity in the structure of the functional relationship between the indicators used to construct a composite measure.

The UNDP has provided one of the most well-known and frequently used composite indicators of development in the form of the HDI. Initially, the HDI was based on the arithmetic mean of three core dimensions: living standards (with income as a proxy), education and health. As the functional form of the index received substantial criticism (see, for instance, Ray, 2008), an attempt was eventually made to improve the aggregation function by using a geometric mean (UNDP, 2010; Klugman et al., 2011). The explicit aim involved ''address[ing] one of the most serious criticisms of the linear aggregation formula, which allowed for perfect substitution across dimensions" (UNDP, 2010, p. 216).

This approach makes it possible to account for the degree of substitution between dimensions, an aspect that becomes increasingly important as the number of dimensions and complexity of the overall index expands (see Section 2). Although the question of substitution between dimensions is receiving greater attention in the literature (Anand & Sen, 1997; UNDP, 2010), there is no consensus on how to manage multiple dimensions with complex linkages and complementarities when it comes to integrating them into a single indicator of development.

To address this issue, Mauro et al. (2018) have developed the MSI, a new method of aggregation capable of taking account of the inter-connections between dimensions while avoiding the tendency of the geometric mean to collapse to zero (in the case of variables with zero values) or to values approaching zero (in the case of variables with values close to zero).[20] Biggeri and Mauro (2018) apply this approach to an index that integrates civil and political freedoms and environmental aspects of development into the HDI alongside the three original dimensions. Their approach provides a possible solution to the so-called 'inescapable [element of] arbitrariness' involved in determining the order of the mean (Anand & Sen, 1997; Bourguignon & Chakravarty, 2003).

The basic idea behind the MSI is the possibility of assigning each unit in the analysis a different degree of substitution, according to a function *g* that allows greater flexibility in the management of synergies and trade-

[20] Guijarro and Poyatos (2018) use the geometric mean to calculate a composite SDG index for the EU-28 countries.

offs between heterogeneous dimensions. In its most general formulation, using a standard data matrix with *n* observations and *k* variables, the MSI index for a generic unit (countries in our case) *i* is:

$$MSI_i = 1 - \left[\frac{1}{k}\sum_j (1 - x_{ij})^{g(x_i)}\right]^{\frac{1}{g(x_i)}} \qquad (1)$$

Where $g(x_i)$ is a function of the i-th generic row of matrix, while $g(\cdot) \geq 1$ and j represents the dimensions. The function $g(\cdot)$ allows a high degree of flexibility in the MSI. Following Mauro et al. (2018), further assumptions on the structure of substitution rates relating to the units under analysis can lead to more detailed and complex reiterations of the functional form of $g(\cdot)$. A generic choice for the function $g(\cdot)$ could be:

$$g(x_i) = \begin{cases} \frac{b}{a} & if\ \mu < a \\ \frac{b}{\mu} & if\ a \leq \mu < b \\ 1 & if\ \mu \geq b \end{cases}$$

Where μ is the arithmetic mean of x_i and a and b $(0 \leq a < b \leq 1)$ are two thresholds selected so that all units above b (or below a) have their achievements aggregated under the assumption of an almost perfect (or complementary) substitution rate.

Consequently, any theoretical considerations concerning the structure of substitution rates between achievements can be easily managed. Table 3 summarises the options for managing substitutability according to different aggregation procedures, including the MSI proposed here.

Table 3. Comparison across different aggregation procedures

	Reward synergies	*Substitutability*	*MRS flexibility**
Arithmetic mean	No	Perfect	None
Higher order means	Yes	Not perfect	None
Geometric mean	Yes	Not perfect	Limited
MSI	Yes	Not perfect	High

* MRS flexibility is the theoretical rate at which a country is ready to trade achievement in one dimension or SDG in exchange for progress in another dimension or SDG, while maintaining the same overall index score.

Source: Authors

The MSI aggregation procedure penalises heterogeneity in the achievements of a unit as a function of the overall level reached. In this regard, we tested the behaviour of the MSI through a comparison with other common functions used for composite indicators, investigating the behaviour of each aggregation approach only as a function of the degree of variability experienced by each unit. The results of our simulations[21] reinforced the choice of the MSI method given the theoretical background regarding heterogeneity penalisation.

[21] We performed three different simulations, on 6 variables measured across 20 countries, calculating the MSI, the geometric mean, and some well-known aggregation functions (i.e. Logistic, Liptak and Fisher functions; see Di Tommaso, Tassinari, Bonnini, & Marozzi, 2017). All the variables used in the analysis are bounded between 0 and 1, and each simulation was set at a different overall average level. As a result, in each of the three simulations, all 20 countries share the same arithmetic mean, but different variability among achievements. The simulations were set at three progressive levels of the arithmetic mean, namely 0.2 (low), 0.4 (intermediate) and 0.6 (high). The Liptak and

The primary contribution of the MSI relates to the possibility of penalising heterogeneity (or rewarding homogeneity) between achievements across dimensions in terms of freedom of choice for the units of analysis (countries in our case). For example, large variations across dimensions could be more heavily penalised in countries with low levels of well-being while similar variations could be less severely reprimanded in countries with higher levels of well-being. The MSI permits clear and transparent decisions on the degree of substitution among different dimensions in the aggregation procedure that would otherwise have theoretically weak justifications and/or would be relegated to subjective weighting systems.

In this paper we use a tailored version of the MSI to propose an alternative approach to aggregate the goals, targets and indicators featured in the SDGs in an integrated way. As we have seen, the arithmetic mean proposed by Sachs and associates for the SDG Index fails to consider the heterogeneity of achievements, both within and between goals. More specifically, their approach assumes perfect substitution between all indicators within a goal, as well as across different goals. In contrast, the MSI approach provides a flexible method for relaxing this unrealistic assumption.

It is worth noting that while the geometric mean employed in the new HDI takes account of the degree of substitution between dimensions, it fails to do so in a flexible way that can be readily applied to different scenarios. In contrast to the geometric mean, the MSI method encounters no problems in cases where specific dimensions score zero (or close to zero), and therefore constitutes a more robust approach.

In the aggregate index for SDGs we are proposing $a = 0$ and $b = 1$ with $g(x_i) = \mu^{-1}$ where μ is the mean. Our application of the MSI adjusts the SDG Index to create a new 'Integrated Sustainable Development Index' – or 'I-SDI' – which can be summarised as follows for each country *i*:

$$I - SDI_i = 1 - \left[\frac{1}{17}\sum_{j=1}^{17}\left(1 - x_{ij}\right)^{\frac{1}{\mu_j}}\right]^{\mu j} \qquad (2)$$

Where μ_j s the average score for the 17 SDGs.

It is possible to capture the synergies within each goal using the MSI approach by introducing the I-SDI2. The '2' indicates that the MSI method is used twice: first to calculate an index for each specific goal (replacing the arithmetic mean); and then to calculate the overall index between goals (as for I-SDI). Thus, for the I-SDI2 firstly we first apply, for each country *i*, and for each of the seventeen goals *d*, in turn, the following formula:

$$I - SDI_{di} = 1 - \left[\frac{1}{n}\sum_{j=1}^{nd}\left(1 - y_{ij}\right)^{\frac{1}{\bar{y}_j}}\right]^{\bar{y}_j} \qquad (3)$$

Where n_d is the number of the indicators pertaining to each goal *d* and $\bar{y}_d$ is its average. (Notice that at this stage this index can also be used in conjunction with the dashboards approach).

The I-SDI2 is then calculated as follows:

$$I - SDI2_i = 1 - \left[\frac{1}{17}\sum_{d=1}^{17}\left(1 - I\,SDI_{di}\right)^{\frac{1}{\overline{I\,SDI}_{di}}}\right]^{\overline{I\,SDI}_{di}} \qquad (4)$$

the Logistic functions as well as the geometric mean were severely sensitive to high levels of heterogeneity. The Logistic function seems to be more robust, at least for low overall levels, while the MSI remains very robust for every level of heterogeneity and every overall level of achievement. For any level of overall achievement, the general behaviour of the functions remains approximately the same. The geometric mean and the MSI decrease as heterogeneity rises, while the other three functions tend to increase with heterogeneity.

Where $\overline{I-SDI}_{di}$ are calculated through formula (3).

This new index can be regarded as an alternative to the I-SDI in cases where we wish to give greater prominence to trade-offs and synergies between targets and indicators within goals.

5. Results and discussion

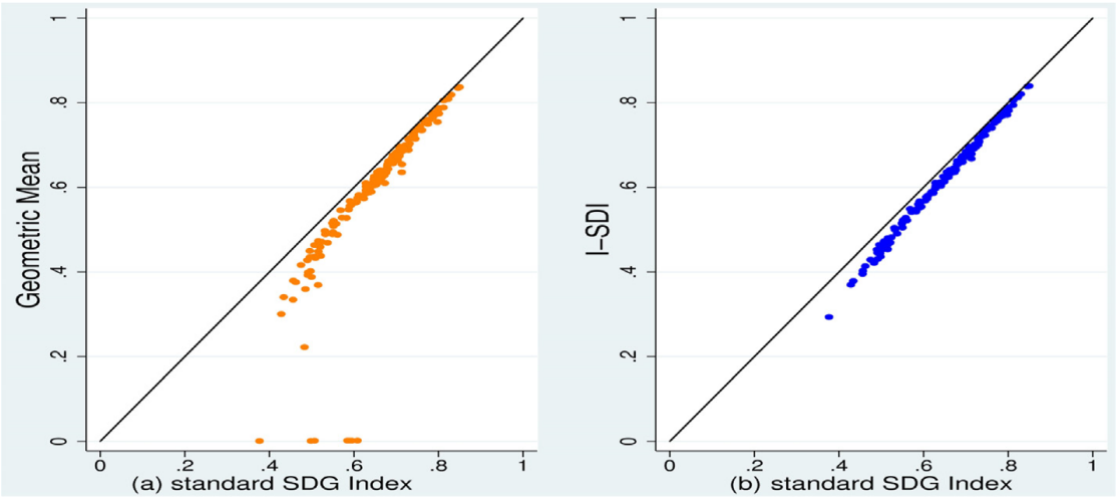
In this section, we use the full dataset for the 2018 SDG Index provided by Bertelsmann Stiftung and the SDSN to calculate: i) the Integrated Sustainable Development Index (I-SDI) by applying the MSI method to aggregate scores across the individual SDG indices computed by Sachs et al. (2018); and ii) the Integrated Sustainable Development Index 2 (I-SDI2) by applying the MSI method a second time to aggregate scores within each goal as well as between goals (see Section 4).

5.1. Enhanced aggregation across the SDGs

Using this data, Fig. 1 compares the standard SDG Index computed through the arithmetic mean with the results of a similar exercise where the results are aggregated across dimensions using the geometric mean instead (panel a) and with the I-SDI computed through the MSI method (panel b).

Each data point in these graphs represents a single country. The analysis shows that the MSI method of aggregation is better placed to take account of heterogeneity than the geometric mean (that falls to 0 for some units) without over-penalising countries with low overall SDG performances. This is especially true when dealing with large numbers of indicators (some of which may exhibit very low scores), which raises the possibility that composite scores may collapse to zero (see panel a).

Figure 1. The geometric mean and our I-SDI compared with the standard SDG Index



Source: Authors

Table 4 reports results for selected countries that experience either high or low heterogeneity in terms of performance across SDGs. For each composite measure, the magnitude of the decrease (or increase) with respect to the standard SDG Index is reported in percentage terms. The new I-SDI, as well as the geometric mean, penalize heterogeneity producing lower scores than the original SDG Index that relies on the arithmetic mean and the assumption of perfect substitution between dimensions.

As Table 4 shows, these indexes produce similar results for countries with low heterogeneity across the 17 SDGs. As their achievements are homogeneous, the assumption of perfect substitution between dimensions holds, and both the I-SDI and the geometric mean produce results similar to the arithmetic mean.

In Table 5 we report results for selected countries that show larger differences in performances across development goals.

As the standard deviation of achievements increase, the assumption of perfect substitution becomes less credible. Countries with higher variability (greater variations across goals) are penalized by both the I-SDI and the geometric mean. The penalization that emerges from the geometric mean is a function of the heterogeneity of achievements only (i.e. the variation between different indicators), while the penalization that arises from the I-SDI is also associated with the overall level of SDG achievement for each country. In contrast to the geometric mean, the I-SDI penalizes trade-offs to a greater (smaller) extent for those countries with lower (higher) aggregate SDG scores. In other words, the I-SDI is sensitive to aggregate development levels as lower scoring units are penalized more than higher scoring units (although less so than with the geometric mean as comparing the two panels in Fig. 1 shows). In particular, countries with a medium-high degree of heterogeneity across dimensions are significantly penalized by the geometric mean but are not so harshly penalised by the I-SDI. Notice that the level of penalization introduced by the geometric mean appears to be excessive in the presence of extreme deprivations in specific goals (this is due to the functional form of the index that is ultra-sensitive to low values). In such situations, the I-SDI appears to be more robust, as component values approaching zero do not affect the final score as heavily.

The difference between the arithmetic mean and the I-SDI (column E in Tables 4 and 5) can be regarded as a measure of heterogeneity. The lower the absolute value of this figure is for a country, the more synergies among SDGs are expected to be achieved.[22] For each country this difference, combined with a correlation matrix among the 17 SDGs and a detailed dashboard, can help identify the synergies and trade-offs that characterise sustainable development to inform policy.

Comparing the rankings obtained from the SDG Index with the rankings that emerge from the I-SDI, produces some striking results. First, the absolute average difference in rankings is greater than 2. Second, more than 80% of countries change their ranking position, with 28% moving by at least three positions. Singapore (down seventeen places, from 43rd to 60th), Cuba (down eight places, from 42nd to 50th), Bosnia and Herzegovina (down seven places, from 71st to 78th) and El Salvador (down seven places, from 92nd to 99th) move the furthest down the table in terms of their overall ranking, while China (up nine places, from 54th to 45th), Ghana (up nine places, from 101st to 92th), Angola (up seven places, from 144th to 137th) and Benin (up six places, from 147th to 141st) experience the greatest improvements.

[22] The correlation of I-SDI with the standard deviation is high 0.837. The corresponding correlations for the arithmetic mean and the geometric mean are -0.694 and -0.726 respectively.

Table 4 Comparing the standard SDG Index, the SDG Index based on the geometric mean and the I-SDI for selected countries at higher, middle and lower scores

Country	A SDG Index score 2018 (0–1)	B Geometric mean score 2018 (0–1)	C I-SDI score 2018 (0–1)	D Reduction Geometric Mean on SDG Index	E Reduction I-SDI on SDG Index	F SDG Index Rank 2018	G Rank Geometric Mean	H Rank I-SDI	I Rank difference SDG Index vs I-SDI
Sweden	0.85	0.84	0.84	−1.7%	−1.4%	1	1	1	
Denmark	0.85	0.83	0.84	−1.4%	−1.0%	2	2	2	
Finland	0.83	0.82	0.82	−1.5%	−1.4%	3	3	3	
Germany	0.82	0.81	0.81	−1.7%	−1.3%	4	4	4	
France	0.81	0.80	0.80	−1.1%	−1.1%	5	5	5	
Norway	0.81	0.79	0.79	−2.9%	−2.2%	6	6	6	
Switzerland	0.80	0.77	0.78	−3.4%	−2.5%	7	10	9	−2
Slovenia	0.80	0.78	0.79	−2.0%	−1.8%	8	8	8	
Austria	0.80	0.79	0.79	−1.6%	−1.4%	9	7	7	2
Iceland	0.80	0.75	0.77	−5.4%	−3.3%	10	19	15	−5
Ghana	0.63	0.61	0.61	−2.9%	−2.7%	101	87	92	9
Nepal	0.63	0.59	0.60	−6.7%	−4.8%	102	102	102	
Belize	0.62	0.57	0.59	−7.9%	−5.8%	103	106	104	−1
Guyana	0.62	0.58	0.59	−6.6%	−4.8%	104	104	103	1
Kuwait	0.61	0.58	0.58	−4.8%	−4.9%	105	103	105	
Qatar	0.61	0.57	0.57	−5.6%	−5.8%	106	105	108	−2
South Africa	0.61	0.19	0.58	−68.5%	−5.3%	107	150	107	
Lao PDR	0.61	0.57	0.58	−6.8%	−4.8%	108	108	106	2
Cambodia	0.60	0.56	0.57	−6.6%	−5.9%	109	109	109	
Turkmenistan	0.59	0.18	0.55	−70.0%	−6.8%	110	153	114	−4
Benin	0.49	0.43	0.45	−12.6%	−7.6%	147	136	141	6
Niger	0.49	0.36	0.43	−25.9%	−11.9%	148	145	149	−1
Liberia	0.48	0.22	0.42	−53.9%	−12.7%	149	149	150	−1
Nigeria	0.47	0.42	0.43	−12.2%	−9.6%	150	137	148	2
Afghanistan	0.46	0.38	0.41	−18.7%	−10.4%	151	143	151	
Yemen, Rep.	0.46	0.38	0.40	−16.8%	−11.7%	152	142	152	
Madagascar	0.46	0.33	0.40	−26.6%	−13.2%	153	147	153	
Congo, Dem. Rep.	0.43	0.34	0.38	−21.5%	−12.7%	154	146	154	
Chad	0.43	0.30	0.37	−29.8%	−13.6%	155	148	155	
Central African Republic	0.38	0.08	0.29	−78.2%	−22.0%	156	156	156	

Source: Authors

Table 5. Comparing the standard SDG index, the SDG index based on the geometric mean, and the new I-SDI ordered by rank difference for selected countries.

Country	A SDG Index score 2018 (0–1)	B Geometric mean score 2018 (0–1)	C I-SDI score 2018 (0–1)	D Reduction Geometric Mean on SDG Index	E Reduction I-SDI on SDG Index	F SDG Index Rank 2018	G Rank Geometric Mean	H Rank I-SDI	I Rank difference SDG Index vs I-SDI
Singapore	0.71	0.64	0.67	−10.9%	−6.3%	43	73	60	−17
China	0.70	0.68	0.68	−2.5%	−2.2%	54	45	45	9
Ghana	0.63	0.61	0.61	−2.9%	−2.7%	101	87	92	9
Cuba	0.71	0.65	0.68	−8.2%	−4.8%	42	65	50	−8
Bosnia and Herzegovina	0.67	0.61	0.64	−9.4%	−5.6%	71	86	78	−7
El Salvador	0.64	0.59	0.60	−8.0%	−5.8%	92	100	99	−7
Angola	0.50	0.45	0.46	−9.2%	−6.3%	144	130	137	7
United Arab Emirates	0.69	0.66	0.66	−5.2%	−4.7%	60	63	66	−6
Benin	0.49	0.43	0.45	−12.6%	−7.6%	147	136	141	6
Iceland	0.80	0.75	0.77	−5.4%	−3.3%	10	19	15	−5
Colombia	0.67	0.62	0.63	−6.4%	−4.8%	74	81	79	−5
Morocco	0.66	0.64	0.64	−3.4%	−3.2%	77	69	72	5
Iran, Islamic Rep.	0.66	0.64	0.64	−2.9%	−2.9%	82	72	77	5
Cabo Verde	0.65	0.62	0.63	−4.2%	−3.3%	88	84	83	5
Lesotho	0.52	0.37	0.45	−28.3%	−12.0%	135	144	140	−5
Mozambique	0.51	0.46	0.47	−8.5%	−6.8%	138	128	133	5
Burundi	0.50	0.10	0.44	−79.4%	−12.4%	141	155	146	−5
Azerbaijan	0.71	0.69	0.69	−2.4%	−2.3%	45	39	41	4
Greece	0.71	0.69	0.69	−2.4%	−2.4%	48	40	44	4
Uzbekistan	0.70	0.67	0.68	−4.6%	−3.1%	52	52	48	4
Thailand	0.69	0.68	0.68	−2.3%	−2.5%	59	46	55	4
Suriname	0.68	0.66	0.66	−3.6%	−2.5%	67	64	63	4
Montenegro	0.68	0.64	0.64	−6.1%	−5.2%	69	74	73	−4
Nicaragua	0.66	0.62	0.63	−6.5%	−4.5%	76	82	80	−4
Tunisia	0.66	0.64	0.64	−3.4%	−3.3%	78	70	74	4
France	0.81	0.80	0.80	−1.1%	−1.1%	5	5	5	
Norway	0.81	0.79	0.79	−2.9%	−2.2%	6	6	6	
Slovenia	0.80	0.78	0.79	−2.0%	−1.8%	8	8	8	
Belarus	0.76	0.73	0.74	−3.4%	−2.5%	23	25	23	
Spain	0.75	0.74	0.74	−2.1%	−2.0%	25	23	25	
Hungary	0.75	0.73	0.74	−2.0%	−1.9%	26	24	26	
Latvia	0.75	0.73	0.73	−2.0%	−1.8%	27	27	27	
Malta	0.74	0.72	0.72	−2.5%	−2.5%	30	30	30	
Poland	0.74	0.72	0.72	−2.5%	−2.2%	32	31	32	
Sri Lanka	0.65	0.61	0.61	−6.2%	−5.1%	89	93	89	
Saudi Arabia	0.63	0.61	0.60	−3.7%	−4.1%	98	92	98	
Gabon	0.63	0.60	0.60	−4.2%	−4.1%	100	97	100	
Nepal	0.63	0.59	0.60	−6.7%	−4.8%	102	102	102	
Kuwait	0.61	0.58	0.58	−4.8%	−4.9%	105	103	105	
South Africa	0.61	0.19	0.58	−68.5%	−5.3%	107	150	107	
Cambodia	0.60	0.56	0.57	−6.6%	−5.9%	109	109	109	
Ethiopia	0.53	0.49	0.50	−8.1%	−6.1%	128	123	128	
Congo, Rep.	0.52	0.47	0.48	−10.1%	−8.0%	130	126	130	
Djibouti	0.51	0.44	0.46	−13.8%	−9.6%	139	133	139	
Afghanistan	0.46	0.38	0.41	−18.7%	−10.4%	151	143	151	
Yemen, Rep.	0.46	0.38	0.40	−16.8%	−11.7%	152	142	152	
Madagascar	0.46	0.33	0.40	−26.6%	−13.2%	153	147	153	
Congo, Dem. Rep.	0.43	0.34	0.38	−21.5%	−12.7%	154	146	154	
Chad	0.43	0.30	0.37	−29.8%	−13.6%	155	148	155	
Central African Republic	0.38	0.08	0.29	−78.2%	−22.0%	156	156	156	

Source: Authors

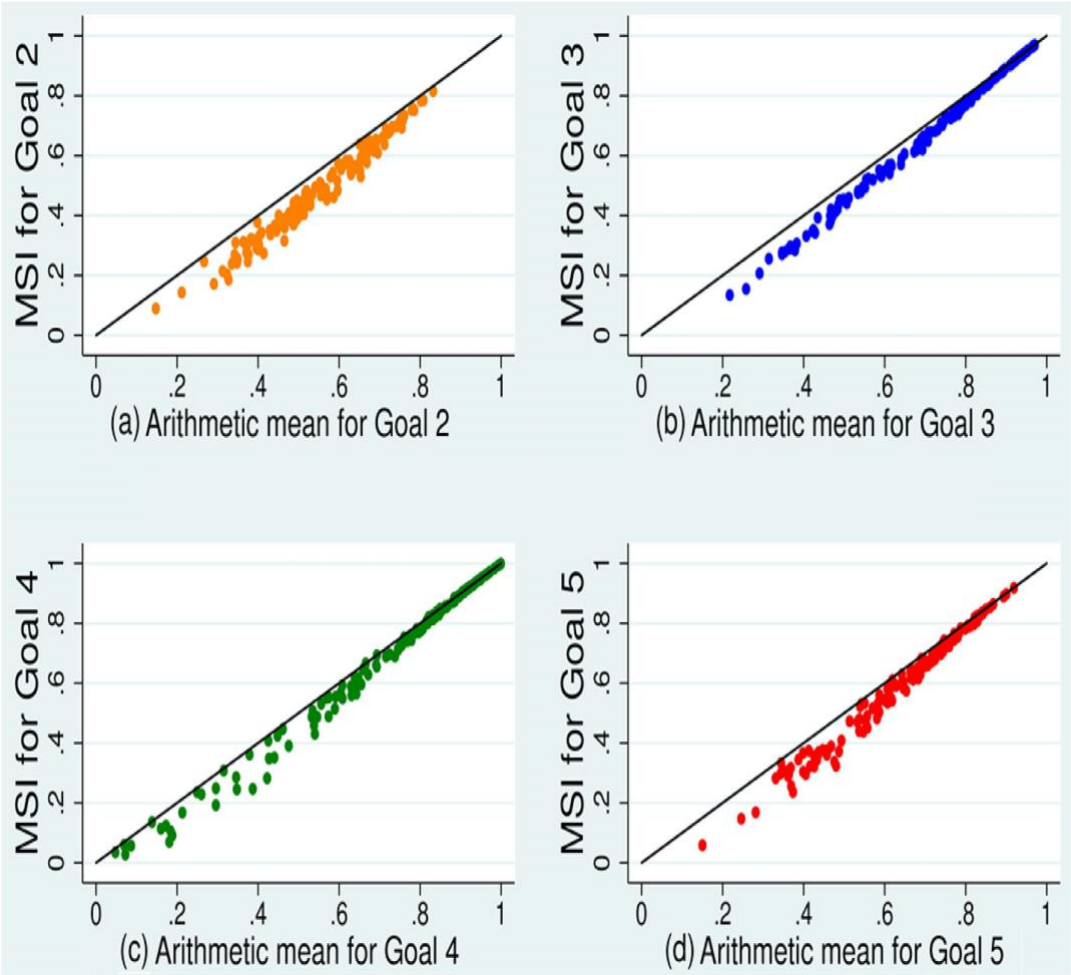
In sum, the I-SDI produces significant changes in country rankings. Countries that are performing well and in a more homogenous and integrated manner are the most rewarded, while countries that perform badly with variations across goals lose several places in their overall ranking.

5.2. Enhanced aggregation within selected SDGs

As mentioned, the MSI aggregation method has also been applied to aggregation within specific goals to better integrate the indicators utilised by Bertelsmann Stiftung and SDSN. For brevity, this paper only reports the results for four goals (SDG2, SDG3, SDG4 and SDG5) to illustrate the differences produced by replacing the arithmetic mean with the MSI method.

Fig. 2 graphically compares the two aggregation methods for the four goals in turn while Tables 6–9 report the corresponding index scores for selected countries for SDG2, SDG3, SGD4 and SDG5 respectively.

Figure 2. Comparing the MSI and arithmetic mean in aggregating indicators for selected SDG



Source: Authors

When comparing rankings for SDG2 (Table 6), we obtain an absolute average ranking difference greater than 5. More than 90 percent of countries change their ranking position, with 65 percent of countries moving by three or more positions. Qatar (down nineteen places, from 60th to 79th), Cyprus (down eighteen places, from 64th

to 82nd), Trinidad and Tobago (down eighteen places, from 88th to 106th) and Georgia (down seventeen places, from 76th to 93rd) fall the furthest in terms of their ranking, while Albania (up eighteen places, from 105th to 87th), Uzbekistan (up eighteen places, from 45th to 27th), Tajikistan (up seventeen places, from 132nd to 115th) and the Philippines (up sixteen places, from 87th to 71st) improve the most.

When comparing rankings for SDG3 (Table 7), we obtain an absolute average ranking difference greater than 1. Around 55 percent of countries change their ranking position, with 16 percent of countries moving by three or more places. Belarus (down five places, from 54th to 59th), Russia (down five places, from 73rd to 78th), Montenegro (down four places, from 70th to 74th), Pakistan (down four places, from 123rd to 127th) and Tanzania (down four places, from 133rd to 137th) fall the furthest in terms of their ranking, while Uganda (up six places, from 136th to 130th), Algeria (up four places, from 80th to 76th), Ecuador (up four places, from 79th to 75th) and Moldova (up four places, from 75th to 71st) improve the most.

Comparing different rankings for SDG4 (Table 8), we obtain an absolute average ranking difference greater than 1. About 72% of countries change their ranking position, with 25% of countries moving by three or more positions. Myanmar (down seven places, from 108th to 115th), Iran (down five places, from 57th to 62nd), Tunisia (down five places, from 83rd to 88th), Cambodia (down five place, from 115th to 120th) and Burundi (down five, places from 125th to 130th) fall the furthest down the rankings, while Ghana (up six places, from 116th to 110th), Austria (up six places, from 71st to 65th), and Trinidad and Tobago (up six places, from 60th to 54th) improve the most.

Comparing the rankings produced for SDG5 (Table 9), yields an absolute average ranking difference greater than 3. Around 85% of countries change their ranking position, with 55%of countries moving three or more places. Iran (down fourteen places, from 126th to 140th), Brazil (down eleven places, from 75th to 86th), Thailand (down eleven places, from 87th to 98th) and Lebanon (down eleven places, from127th to138th) fall the furthest down the rankings, while the former Yugoslav Republic of Macedonia (up fourteen places, from 73rd to 59th), Mauritania (up twelve places, from 151st to 139th), Montenegro (up twelve places, from 92nd to 80th) and Cote d'Ivoire (up eleven places, from 142nd to 131st) improve the most.

These results illustrate the importance of adjusting the aggregation of targets and indicators within specific Goals. Amongst other things, variations in performance across indicators may point to different strategic policy options and choices by multi-level actors involved in the implementation of the 2030 Agenda for Sustainable Development.

Table 6. Comparing the scores and rankings between the standard SDG Index and the I-SDI for SDG2 ''Zero hunger".

Country	A Goal 2 SDG2 Index score 2018 (0–100)	B Goal 2 SDG2 Index score 2018 (0–1)	C Goal 2 I-SDI score within 2018 (0–1)	D Goal 2 SDG3 index Rank 2018	E Goal 2 Rank I-SDI within	F Goal 2 Rank difference SDG Index vs I-SDI within
Qatar	58.7	0.59	0.46	60	79	−19
Cyprus	57.0	0.57	0.45	64	82	−18
Trinidad and Tobago	51.3	0.51	0.40	88	106	−18
Georgia	52.9	0.53	0.43	76	93	−17
Tunisia	50.1	0.50	0.40	94	110	−16
United Arab Emirates	65.3	0.65	0.53	43	58	−15
Jordan	46.5	0.46	0.32	115	130	−15
Burundi	41.4	0.41	0.27	126	141	−15
Morocco	50.7	0.51	0.41	91	105	−14
New Zealand	69.6	0.70	0.61	22	35	−13
Bahrain	66.9	0.67	0.58	32	45	−13
Mauritius	49.5	0.50	0.39	99	112	−13
Costa Rica	57.0	0.57	0.47	63	75	−12
Australia	59.6	0.60	0.48	58	69	−11
Kazakhstan	52.2	0.52	0.43	80	91	−11
Jamaica	48.8	0.49	0.37	107	118	−11
Kuwait	65.2	0.65	0.55	44	54	−10
Singapore	71.2	0.71	0.64	20	29	−9
Turkey	56.1	0.56	0.47	67	76	−9
Montenegro	55.5	0.56	0.47	68	77	−9
Sierra Leone	38.2	0.38	0.32	136	128	8
Moldova	62.6	0.63	0.58	52	43	9
Armenia	54.1	0.54	0.49	74	65	9
Venezuela, RB	48.8	0.49	0.43	104	95	9
Kyrgyz Republic	61.7	0.62	0.58	54	44	10
Guyana	59.8	0.60	0.57	57	47	10
Thailand	55.3	0.55	0.51	71	61	10
Cote d'Ivoire	45.1	0.45	0.40	119	108	11
Botswana	36.4	0.36	0.31	142	131	11
South Africa	51.9	0.52	0.47	84	72	12
Cambodia	51.8	0.52	0.47	86	74	12
Myanmar	52.0	0.52	0.48	83	70	13
Paraguay	66.0	0.66	0.64	38	24	14
Bolivia	49.6	0.50	0.45	98	84	14
Bhutan	49.3	0.49	0.44	102	88	14
Iraq	34.4	0.34	0.31	146	132	14
Philippines	51.6	0.52	0.48	87	71	16
Tajikistan	39.8	0.40	0.38	132	115	17
Uzbekistan	65.1	0.65	0.64	45	27	18
Albania	48.8	0.49	0.44	105	87	18

Source: Authors

Table 7. Comparing the scores and rankings between the standard SDG Index and the I-SDI for SDG3 ''Health and well-being".

Country	A Goal 3 SDG3 Index score 2018 (0–100)	B Goal 3 SDG3 Index score 2018 (0–1)	C Goal 3 I-SDI score within 2018 (0–1)	D Goal 3 SDG3 index Rank 2018	E Goal 3 Rank I-SDI within	F Goal 3 Rank difference SDG Index vs I-SDI within
Belarus	81.4	0.81	0.78	54	59	−5
Russian Federation	77.2	0.77	0.73	73	78	−5
Montenegro	78.2	0.78	0.74	70	74	−4
Pakistan	50.7	0.51	0.44	123	127	−4
Tanzania	47.1	0.47	0.40	133	137	−4
Saudi Arabia	82.8	0.83	0.80	47	50	−3
Iran, Islamic Rep.	78.6	0.79	0.75	67	70	−3
Armenia	76.9	0.77	0.73	76	79	−3
Thailand	76.7	0.77	0.73	78	81	−3
Ukraine	69.3	0.69	0.62	97	100	−3
Rwanda	61.2	0.61	0.54	108	111	−3
Ethiopia	47.4	0.47	0.41	131	134	−3
Burkina Faso	47.1	0.47	0.41	132	135	−3
Afghanistan	37.9	0.38	0.28	146	149	−3
Serbia	81.4	0.81	0.79	53	55	−2
Albania	81.0	0.81	0.78	56	58	−2
Bulgaria	80.1	0.80	0.77	60	62	−2
Sri Lanka	79.3	0.79	0.76	64	66	−2
Tunisia	76.3	0.76	0.72	81	83	−2
Venezuela, RB	70.7	0.71	0.65	95	97	−2
Morocco	73.8	0.74	0.71	90	88	2
Bolivia	68.9	0.69	0.66	98	96	2
Cambodia	61.0	0.61	0.57	109	107	2
Zambia	49.9	0.50	0.45	125	123	2
Swaziland	48.9	0.49	0.45	126	124	2
Kenya	48.9	0.49	0.45	127	125	2
Togo	46.5	0.47	0.40	138	136	2
Cameroon	43.5	0.43	0.39	140	138	2
Guinea	36.7	0.37	0.30	148	146	2
Panama	78.4	0.78	0.76	68	65	3
Nicaragua	77.2	0.77	0.75	72	69	3
Nepal	58.7	0.59	0.55	113	110	3
Benin	46.9	0.47	0.41	135	132	3
Colombia	80.8	0.81	0.79	58	54	4
Peru	80.0	0.80	0.79	61	57	4
El Salvador	79.3	0.79	0.77	65	61	4
Moldova	76.9	0.77	0.74	75	71	4
Ecuador	76.7	0.77	0.74	79	75	4
Algeria	76.6	0.77	0.74	80	76	4
Uganda	46.7	0.47	0.42	136	130	6

Source: Authors

Table 8. Comparing the scores and rankings between the standard SDG Index and the I-SDI for SDG4 ''Quality education''.

Country	A Goal 4 SDG4 Index score 2018 (0–100)	B Goal 4 SDG4 Index score 2018 (0–1)	C Goal 4 I-SDI score within 2018 (0–1)	D Goal 4 SDG4 index Rank 2018	E Goal 4 Rank I-SDI within	F Goal 4 Rank difference SDG Index vs I-SDI within
Myanmar	64.3	0.64	0.57	108	115	−7
Iran, Islamic Rep.	84.7	0.85	0.83	57	62	−5
Tunisia	77.9	0.78	0.74	83	88	−5
Cambodia	60.9	0.61	0.55	115	120	−5
Burundi	54.0	0.54	0.43	125	130	−5
Argentina	88.6	0.89	0.87	41	45	−4
Uruguay	83.2	0.83	0.81	65	69	−4
Rwanda	57.4	0.57	0.49	121	125	−4
Benin	38.7	0.39	0.25	137	141	−4
Guinea	18.8	0.19	0.09	147	151	−4
Malaysia	88.6	0.89	0.88	40	43	−3
Jordan	84.8	0.85	0.84	55	58	−3
El Salvador	67.2	0.67	0.63	102	105	−3
Morocco	65.5	0.65	0.60	106	109	−3
Cabo Verde	63.1	0.63	0.56	113	116	−3
Nepal	59.0	0.59	0.51	119	122	−3
Lao PDR	54.6	0.55	0.49	124	127	−3
Bhutan	47.6	0.48	0.39	130	133	−3
Sierra Leone	42.2	0.42	0.28	136	139	−3
Yemen, Rep.	34.8	0.35	0.25	139	142	−3
Afghanistan	6.9	0.07	0.06	155	153	2
Luxembourg	88.4	0.88	0.88	43	40	3
Poland	88.4	0.88	0.88	44	41	3
Panama	79.1	0.79	0.78	79	76	3
Jamaica	66.6	0.67	0.67	103	100	3
Uganda	60.4	0.60	0.57	117	114	3
Congo, Rep.	57.0	0.57	0.55	122	119	3
Congo, Dem. Rep.	53.5	0.54	0.50	127	124	3
Togo	53.2	0.53	0.49	129	126	3
Pakistan	42.5	0.43	0.41	135	132	3
Belize	83.1	0.83	0.83	67	63	4
Botswana	76.1	0.76	0.75	89	85	4
Zambia	63.9	0.64	0.62	110	106	4
Haiti	37.9	0.38	0.36	138	134	4
Nigeria	31.5	0.32	0.31	141	137	4
Tanzania	53.5	0.53	0.51	128	123	5
Djibouti	13.8	0.14	0.14	152	147	5
Trinidad and Tobago	84.1	0.84	0.84	60	54	6
Austria	82.2	0.82	0.82	71	65	6
Ghana	60.8	0.61	0.59	116	110	6

Source: Authors

Table 9. Comparing the scores and rankings between the standard SDG Index and the I-SDI for SDG5 ''Gender equality''.

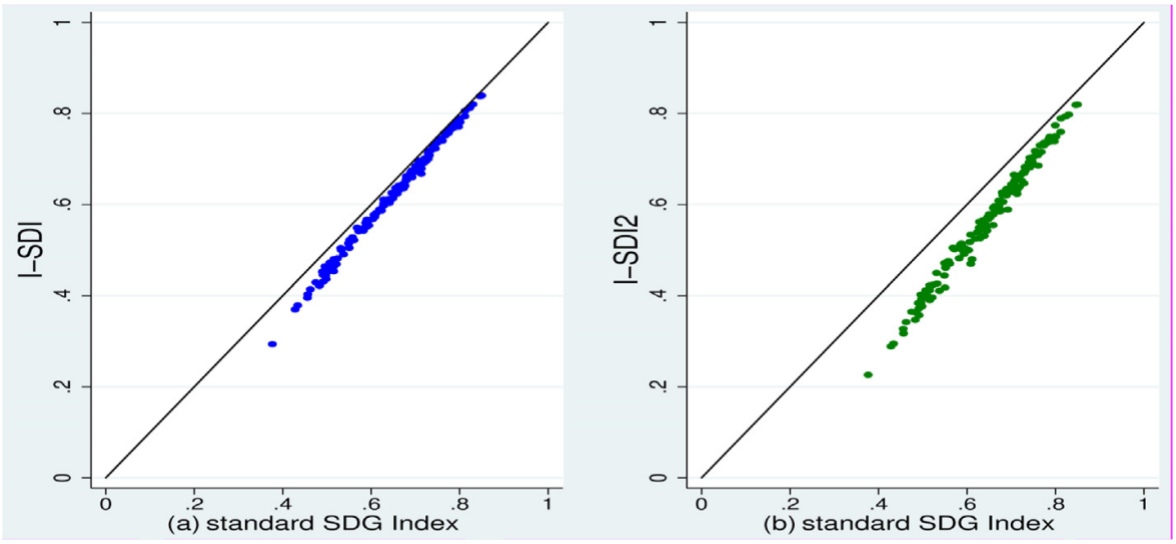
Country	A Goal 5 SDG5 Index score 2018 (0–100)	B Goal 5 SDG5 Index score 2018 (0–1)	C Goal 5 I-SDI score within 2018 (0–1)	D Goal 5 SDG5 index Rank 2018	E Goal 5 Rank I-SDI within	F Goal 5 Rank difference SDG Index vs I-SDI within
Iran, Islamic Rep.	48.0	0.48	0.32	126	140	−14
Brazil	68.3	0.68	0.61	75	86	−11
Thailand	65.3	0.65	0.57	87	98	−11
Lebanon	47.6	0.48	0.34	127	138	−11
Angola	61.8	0.62	0.54	97	106	−9
Guinea	37.4	0.37	0.24	144	153	−9
Hungary	68.1	0.68	0.62	77	85	−8
Malta	64.6	0.65	0.58	88	96	−8
Kuwait	55.8	0.56	0.45	113	121	−8
Congo, Dem. Rep.	40.5	0.41	0.30	140	148	−8
Ireland	74.9	0.75	0.72	40	47	−7
Latvia	72.5	0.72	0.68	54	61	−7
Oman	36.9	0.37	0.26	145	152	−7
Nicaragua	82.9	0.83	0.81	13	19	−6
United States	75.9	0.76	0.72	37	43	−6
Madagascar	73.9	0.74	0.70	49	55	−6
Qatar	54.7	0.55	0.44	117	123	−6
Syrian Arab Republic	42.6	0.43	0.32	136	142	−6
Lithuania	75.3	0.75	0.72	39	44	−5
Colombia	72.0	0.72	0.68	57	62	−5
Iraq	44.7	0.45	0.38	131	126	5
Pakistan	34.4	0.34	0.30	152	147	5
Kenya	69.3	0.69	0.67	70	64	6
Gambia, The	35.5	0.36	0.31	150	144	6
Cabo Verde	61.7	0.62	0.60	98	91	7
Uganda	60.6	0.61	0.58	104	97	7
Suriname	66.8	0.67	0.64	83	75	8
Turkmenistan	61.9	0.62	0.61	96	88	8
Cameroon	58.7	0.59	0.56	107	99	8
Tajikistan	55.1	0.55	0.53	116	108	8
Bosnia and Herzegovina	54.3	0.54	0.53	118	110	8
Gabon	54.0	0.54	0.52	119	111	8
Sudan	38.7	0.39	0.34	143	135	8
El Salvador	69.6	0.70	0.68	69	60	9
Zambia	66.3	0.66	0.64	86	76	10
Djibouti	41.3	0.41	0.37	139	128	11
Cote d'Ivoire	39.9	0.40	0.37	142	131	11
Montenegro	64.2	0.64	0.63	92	80	12
Mauritania	34.4	0.34	0.33	151	139	12
FYROM	69.0	0.69	0.68	73	59	14

Source: Authors

5.3. Enhanced aggregation both within and between SDGs

Fig. 3 presents a comparison between the behaviour of the ISDI, which only takes account of heterogeneity between-goals, and the I-SDI2 that extends our approach to include heterogeneity amongst indicators within-goals, i.e. within-group variability. Both the indexes are compared with the standard approach of the SDG Index, represented by the 45-degree line.

Figure 3. The I-SDI and I-SDI2 compared with the standard SDG Index



Source: Authors

As both versions of the index introduce a degree of penalisation in comparison with the arithmetic mean, all the data points (representing individual countries) fall under the 45-degree line in Fig. 3. Nonetheless, panel (b) indicates that the I-SDI2 is associated with a significant increase in the level of penalisation, especially for countries towards the bottom-left, representing the most deprived countries. The I-SDI can be interpreted as a special case of the ISDI2, where the indicators for specific goals achieve the same score (or perhaps in cases where it is reasonable to assume perfect substitution between indicators).

Table 10 reports indicator scores and rankings for selected countries for the I-SDI and the I-SDI2. According to the results the I-SDI2 applying the MSI method twice penalises heterogeneity in SDGs results more heavily than in the I-SDI.

Table 10. Comparing the scores and rankings between the standard SDG Index, the I-SDI and the I-SDI2 for selected countries.

	A	B	C	D	E	F	G	H	I	J	K
Country	**SDG Index score 2018 (0-1)**	**I-SDI score 2018 (0-1)**	**I-SDI2 2018 (0-1)**	**Rank SDG Index 2018**	**Rank I-SDI 2018**	**Rank I-SDI2 2018**	**Rank difference SDG Index vs I-SDI**	**Rank difference SDG Index vs I-SDI2**	**Penalization due to heterogeneity between SDGs**	**Penalization due to heterogeneity whithin SDGs**	**Total penalization**
Sweden	0.850	0.838	0.704	1	1	4	0	-3	-1.4%	-16.0%	-17.2%
Denmark	0.846	0.838	0.707	2	2	3	0	-1	-1.0%	-15.6%	-16.4%
Finland	0.830	0.819	0.685	3	3	6	0	-3	-1.4%	-16.4%	-17.5%
Germany	0.823	0.812	0.678	4	4	10	0	-6	-1.3%	-16.6%	-17.6%
France	0.812	0.803	0.676	5	5	11	0	-6	-1.1%	-15.8%	-16.7%
Norway	0.812	0.794	0.667	6	6	16	0	-10	-2.2%	-16.1%	-17.9%
Switzerland	0.801	0.781	0.669	7	9	15	-2	-8	-2.5%	-14.4%	-16.5%
Slovenia	0.800	0.786	0.635	8	8	34	0	-26	-1.8%	-19.2%	-20.6%
Austria	0.800	0.789	0.674	9	7	13	2	-4	-1.4%	-14.5%	-15.7%
Iceland	0.797	0.771	0.624	10	15	45	-5	-35	-3.3%	-19.1%	-21.8%
Ghana	0.628	0.611	0.562	101	92	85	9	16	-2.7%	-8.0%	-10.5%
Nepal	0.628	0.597	0.557	102	102	89	0	13	-4.8%	-6.8%	-11.3%
Belize	0.623	0.587	0.554	103	104	90	-1	13	-5.8%	-5.6%	-11.1%
Guyana	0.619	0.589	0.538	104	103	103	1	1	-4.8%	-8.6%	-13.0%
Kuwait	0.611	0.581	0.471	105	106	119	-1	-14	-4.9%	-19.0%	-23.0%
Qatar	0.608	0.573	0.460	106	108	124	-2	-18	-5.8%	-19.7%	-24.3%
South Africa	0.608	0.586	0.586	107	105	71	2	36	-3.7%	0.0%	-3.7%
Lao PDR	0.606	0.577	0.517	108	107	107	1	1	-4.8%	-10.4%	-14.7%
Cambodia	0.604	0.568	0.500	109	109	112	0	-3	-5.9%	-12.1%	-17.2%
Turkmenistan	0.595	0.554	0.554	110	115	91	-5	19	-6.8%	-0.1%	-6.9%
Benin	0.490	0.453	0.384	147	141	144	6	3	-7.6%	-15.2%	-21.6%
Niger	0.485	0.427	0.355	148	149	149	-1	-1	-11.9%	-16.9%	-26.8%
Liberia	0.483	0.422	0.347	149	150	150	-1	-1	-12.7%	-17.7%	-28.2%
Nigeria	0.475	0.429	0.365	150	148	147	2	3	-9.6%	-15.0%	-23.2%
Afghanistan	0.462	0.414	0.316	151	151	152	0	-1	-10.4%	-23.6%	-31.6%
Yemen, Rep.	0.457	0.403	0.301	152	152	153	0	-1	-11.7%	-25.3%	-34.0%
Madagascar	0.456	0.396	0.327	153	153	151	0	2	-13.2%	-17.3%	-28.2%
Congo, Dem. Rep.	0.434	0.379	0.295	154	154	154	0	0	-12.7%	-22.2%	-32.0%
Chad	0.428	0.370	0.278	155	155	155	0	0	-13.6%	-25.0%	-35.1%
Central African Republic	0.377	0.294	0.238	156	156	156	0	0	-22.0%	-19.1%	-36.9%

Source: Authors

It is beyond the scope of this paper to breakdown and analyse the determinants of variations or changes in scores and rankings for specific countries. However, it is clear the 2030 Agenda for Sustainable Development depends fundamentally on the capacity to reward positive synergies and minimize trade-offs by designing appropriate systemic strategies (ICSU, 2017; ODI, 2017). For example, Pradhan et al. (2017, p. 9), has suggested that policies intended to minimize trade-offs with SDG12 (Responsible consumption and production) are likely to be the most effective in leveraging the agenda for sustainable development. Other authors argue that potential trade-offs are contingent on national circumstances and prevailing levels of development (ICSU, 2017; Mainali, Luukkanen, Silveira, & Kaivo-oja, 2018; Nilsson, Griggs, & Visbeck, 2016; Singh et al., 2018). It follows that investigating whether higher scores and rankings depend primarily on success in terms of tackling different goals and targets or whether relative performance has more to do with the structure of a country's economy and initial background conditions would be helpful for developing integrated policy measures to achieve economic, social and environmental development.

6. Final remarks

The pursuit of each SDG is a necessary but not a sufficient condition for the achievement of a balanced and integrated form of sustainable development. Although goals and targets are not independent of each other, they are indivisible in the sense that they make unique contributions to overall development. In other words, the pursuit of a balanced and integrated set of SDGs is a necessary condition for the success of Agenda 2030.

It follows that there is a pressing need to analyze and monitor the SDGs through an effective aggregate indicator of sustainable development that can complement dashboard and scorecard approaches. Like other renowned composite indicators that have a clear advocacy role and policy impact (most notably, the HDI) such a metric, despite well-known limitations, is relevant for monitoring overall progress towards sustainable development across countries, ensuring transparency and accountability at all level of governance, and shaping new strategic policy visions for sustainable development.

Although the SDG Index introduced by Bertelsmann Stiftung and SDSN (Sachs et al., 2016, 2017, 2018) is an important step forward, it represents a departure from the 2030 Agenda insofar as it fails to aggregate goals and indicators in an integrated and balanced way. In this respect, it does not adequately account for the relevant trade-offs and synergies between goals or for those between targets and indicators within specific goals.

This paper has overcome these difficulties by introducing a new class of indexes inspired by the MSI approach. The result is the Integrated Sustainable Development Index (I-SDI) and the adjusted I-SDI2 which are better placed to allow for the integrated nature of the SDGs by incorporating synergies and conflicts between goals and targets. These methodological innovations are crucial if such an index is to actively embrace an indispensable part of the rationale behind the universal commitment to sustainable development. In this respect, our approach helps ensure that the metric is fit for the intended purpose and can help marshal further acceptance among peers (Rosen, 1991).

Like the SDG Index, the I-SDI is not intended to replace the global dashboard of indicators for monitoring the SDGs. But, if combined with dashboards and scorecards, it does have huge potential for identifying priority areas

for complementary actions across Goals, tracking overall progress, and permitting international comparisons. It also has political value insofar as it encourages countries to appreciate the importance of pursuing synergies between goals, targets and indicators within an overarching development strategy.

As expected, the results of our analysis confirm that the I-SDI outperforms that SDG index in terms of recognizing positive and negative synergies across goals. It also outperforms a recalculated version of the SDG index based on the geometric mean, which tends to over penalize low scores in specific goals. This problem becomes especially acute in cases where there are a relatively large number of dimensions (such as this, 17 SDGs in total). This approach can be extended further through the introduction of the I-SDI2, an index that also penalizes heterogeneity among indicators within goals, which is especially relevant for countries with low levels of overall sustainability.

This paper does not claim to solve the arbitrariness issue (in selecting indicators and corresponding weights) but does propose an index that permits a more flexible approach for managing the interactions between various dimensions, yielding different scores and rankings. The tools provided by this approach encourage a better understanding of the dynamics that emerge from the synthesis between goals and indicators. Although a certain degree of arbitrariness may well be inescapable (Anand & Sen, 1997), a deeper understanding of the linkages and interactions between goals and indicators, and a more flexible approach to monitoring them can significantly increase awareness and consciousness of the selection of parameters as well as subsequent policy choices.

Future research could consider how the I-SDI and the I-SDI2 can be analysed from a dynamic perspective by identifying SDG patterns, outcomes and performance within and between countries and over time, and by considering the use of micro-data to include inequality within countries as well as investigating SDG performance at sub-national levels. At global level, longer term time series data would allow better understanding of the real synergies and trade-offs among SDGs, as well as of pathways for sustainable development over time. At country level, it would be worth evaluating strategies towards the SDGs in the medium and short run by attempting to disentangle the role of policies, structural background conditions and external factors in efforts to bolster synergies and mitigate trade-offs. Finally, the MSI aggregation method used in this paper can be easily applied to other databases and indices to enhance the integration of different dimensions within composite measures of sustainable development, serving the need of policy-makers across the world to strategically combine environmental, social and economic aspects of sustainability.

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PAPER 3: INDUSTRIAL POLICY AND SOCIETAL GOALS: A NEW LOOK AT THE AMERICAN CASE

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Abstract

The role of the state has always been a contentious issue with strongly polarized positions within the economic debate (Krueger, 1990; Le Grand, 1991; Chang, 1994; Pressman, 2006; Lerner, 2009; Chang and Grabel, 2014). This is even stronger when broadening the attention to the relationships between the economy and society, and more controversial when dealing with Industrial Policy (IP) throughout America's history.

Within a perspective that defines industrial policy as "all government interventions on production dynamics driven by national societal goals" (Di Tommaso and Schweitzer, 2013; Di Tommaso et al., 2013; Di Tommaso et al., 2017), this paper aims at analyzing the long history of industrial policies in the US and interpreting it with regards to the social aspects and the promotion of an American model of society.

This objective might be considered surprising if one thinks of the United States as having a consistent political rhetoric and economic history characterized by an unconditional confidence in the market and individual economic freedom, along with a tradition of opposition to government interference. Anyway, this paper informs the debate about government intervention by going beyond this ideological perspective. In particular, we discuss the policy practices of the US government and provide a new look at the historical experience of the reality of American industrial policy.

In particular, we compare the most recent and present practices of Obama (2009-2016) and Trump (from January 2017 to January 2019) administrations with the country's historical policy precedents, starting from the days following political independence – when the US wanted to gain industrial and economic independence – and tracing government intervention through the various stages of the country's industrialization. This long-run analysis provides also insights that allow to better focus the current debate on today's industrial policy.

Keywords

Industrial policy; US government; Industrialization; Societal goals; Long-run perspective; rhetoric; American society

1. Introduction

1.1 Industrial policy as the nexus between goals, targets, and tools

Within the debate on industrial policy, it is still true that "any random collection of six economists is sure to produce at least a dozen different opinions on the subject" (Gerosky 1989, 20). This paper conceives the notion of industrial policy as "all government interventions on production dynamics driven by national societal goals" (Di Tommaso and Schweitzer 2013, 3). It is based on three main policy elements: *targets*, *tools*, and *goals*.

In this framework, industrial policies can target manufacturing, but also other sectors (services, construction, and agriculture), and companies, regions, population subgroups, or other relevant actors and networks (e.g., universities). Thus, industrial policy is not restricted to industrial production, but has a wide range of *targets*. Moreover, industrial policies may adopt a variety of policy tools, ranging from financial measures to new rules that modify incentives along with individual and collective behaviours (Di Tommaso and Schweitzer 2013; Barbieri et al. 2019).

Finally, in our interpretation, industrial policy is not just about targets and tools; rather, it is about *societal goals* as defined by each specific community of people, groups, and interests. Industrial policy entails specifying "goals," "targets," and "tools," and should be conceived of as a political intervention to redesign our future, favouring (or preventing) a transformation of industry, the economy, and society.

This conception of industrial policy connects us to the debate within *social economics* about the relationships between the economy and society, as we agree that "economic values cannot be separated from social values, and that economic relationships are framed by broader social relationships" (Davis and Dolfsma 2008, 2). Despite the neglect in mainstream thinking about the role of societal values, it is increasingly evident that governments adopt belief systems and values that shape and define their policies, thereby influencing the transformation of their economies and societies. In line with Dannreuther and Kessler (2008), we consider it fundamental to engage with the question of the role of the state in economic and societal processes, overcoming the separation of the public and private spheres.

From this perspective, this paper analyses the long history of industrial policy in the United States, especially in relation to promoting an American model of society. In the spirit of cross-fertilization that characterizes social economics (Pressman 2006; Davis and Dolfsma 2008; Elsner 2017), this paper analyses the role of the US government regarding industrialization as driving the transformation of the economy and the society in the long run.

1.2 Industrial policy and societal goals in the United States

Strongly polarized positions have always characterized economic debates regarding the role of the state (Krueger 1990; Le Grand 1991; Chang 1994; Pressman 2006; Lerner 2009; Chang and Grabel, 2014). Polarization is even greater regarding industrial policy throughout the history of the US. On the one side, government interference in markets has been thought to lead to failure and inefficiencies; on the other side is the idea that economic (and social) development *must* rely on government guidance. Despite emphasis on the strength of free markets, government policy has been interventionist through US history (Bianchi and Labory 2011; Cowling and Tomlinson 2011; Wade 2012; Stiglitz and Lin 2013; Di Tommaso and Schweitzer 2013; Di Tommaso et al. 2019).

Following the global recession that started in 2008, governments have intervened (regardless of whether they advocated austerity or expansive fiscal policies) to limit the severity of the decline and promote economic recovery. They have bailed out failing firms and used both fiscal and monetary policies to stimulate economic growth. These measures were often aimed at protecting and promoting specific domestic industries. Generally, these actions were motivated by short-term economic, social, and political necessity, although in some cases interventions were more ambitious, aiming to achieve more complex structural adjustment and national societal goals.

The question motivating this paper concerns the role of industrial policy by the US federal government. The paper informs this debate by going beyond the ideological perspective that opposes government interference with unconditional confidence in the market and individual economic freedom.

In particular, we discuss the policy *practices* of the US government and provide a new look at the historical experience of American industrial policy. In particular, we compare practices of the Obama (2009–2016) and Trump (January 2017 to January 2019) administrations with the country's historical policy precedents—starting from the days following independence and then tracing government intervention through the various stages of the country's industrialization. This long-term analysis provides insights into current debates on industrial policy.

2. Laying the foundations for sustained industrialization

2.1 "The true wealth and prosperity of the state": manufacturing independence and catching up

The *Report on the Subject of Manufactures*, presented by Secretary of the Treasury Alexander Hamilton to the United States Congress in 1791, was the starting point of a long-term economic policy program for industrializing and structurally transforming the US. The promotion of the (infant) American industry— through tariffs on imports, prohibitions on exporting innovative machinery, direct subsidies to the industries considered to be strategic, tax exemptions on production of raw materials, and support for improvement of national infrastructures (Hamilton 1791/2007)—laid out a strategic vision for the future of US industry, the economy, and society.

Initially, Congress was not as enthusiastic about these proposals as Hamilton hoped for. However, over a period of thirty years, duties on foreign industrial products grew, reaching 40 percent, and they remained at high levels until the first half of the twentieth century. Hamilton's interventionist approach characterized the first growth phase of US industry (Chang 2002).

Despite regulation and antitrust policies (e.g., the Sherman Antitrust Act and the Clayton Antitrust Act, respectively in 1890 and 1914) designed to promote competition, "special cases" began to appear due to their strategic importance— rail, iron and steel, automotive, and maritime, among others.

In the early decades of the nineteenth century, the government planned, financed, and coordinated the railway industry (Cochran 1950; Hill 1951; Carter 1968; Lloyd 1982; Dobbin 1994), gradually substituting the role initially played mostly by state and local governments, in partnership with the private sector. The government was also active in price and competition regulation. Beginning in 1860 the federal government offered land, guarantees,

and loans for the construction of four transcontinental lines. It soon regulated the entire US rail system (Dobbin 1994).

From independence onward, high tariffs protected the iron and steel industry. In the late nineteenth century, the creation of cartels and strategic alliances was favoured, leading to a national oligopoly (Nester 1997; Wilson 2006). During two World Wars and conflicts in Korea and Vietnam, the steel industry was considered a strategic sector, necessary to support the United States military (Di Tommaso and Schweitzer 2013).

The automotive industry also attracted the attention of the federal government. In 1908, Henry Ford launched the famous Model T. Since then, specialization and mass consumption have radically changed the organization of work, industry, and society in America and around the world. In this framework of entrepreneurial dynamism, the US government decided to support the development of this infant industry. Protection from foreign competitors was ensured through tariffs on imported goods, which fluctuated between 25 and 50 percent from 1913 until 1934, then in subsequent years stabilized at about 10 percent. For a long period, the domestic automobile industry took advantage of protection from foreign competition, of strong and continuing public demand, and of massive government investments in equipment, technology, and infrastructure. Under these conditions, the development of the American automobile industry coincided with the development of a de facto oligopoly comprising three major manufacturers: Ford, Chrysler, and General Motors (GM).This situation was permitted and encouraged by a "special relationship" between the government and the auto industry, which began with the First World War (Nester 1997; Di Tommaso and Schweitzer 2013).

Finally, during World War I, the maritime industry was given public money to construct an American naval fleet, which was sold to the private sector at the end of the war at below market price. This policy provided substantial aid to the shipbuilding industry, but it reduced demand for the construction of new ships, creating problems in the 1920s. In 1928 the government decided to intervene to save the industry from collapse. With the start of World War II, as with World War I, the government initiated a comprehensive program for constructing warships and forced the domestic industry to respond (Bingham and Sharpe, 1998).

For his ideas about the need to for the US to catch up to leading industrialized countries, Alexander Hamilton can be considered as America's first proponent of industrial policy. His approach left a footprint on early industrialization, and the use of industrial policy to prepare for several wars, and finally the establishment of global industrial leadership.

2.2 "New wars and new deals": industrial and social transformation in critical times

Public support for strategic industries, the embeddedness of national cartels and oligopolies in some sectors, and the presence of a public hand in managing large sectors of national industry had become structural features of American capitalism by World War I. The war itself led to new government–industry relations. The interests of large companies, their development of rents, and the establishment of lobbies to negotiate with the government found new momentum thanks to the opportunities offered on the domestic and foreign markets:

> entry into World War I was part of the transformation of American society that had already begun ... American leaders had turned to overseas economic expansion as the strategy of recovery and future prosperity before the United States became involved in the conflicts as either a non-fighting

> belligerent or an active military protagonist ... the system began to produce welfare and a sense of community simply as by-product of warfare.
>
> (Williams 2011, 415–416)

The Great Depression represented another "special moment" for government–industry relations in the United States, allowing substantial intervention into the national industrial system and, more broadly, toward societal goals. The National Industrial Recovery Act of 1933 had the government acting as a direct employer, along with providing contracts for public goods and services in the private sector. This New Deal effort was inspired by a Keynesian approach to economic recovery (Di Tommaso et al.2019). Another program, the Buy American Act of 1933, placed limits on the purchase of foreign products by the government, thus supporting a wide variety of domestic industries.

Policies not only provided financing for businesses and industries in need of capital through the Reconstruction Finance Corporation (RFC),[1] they also allowed the creation of cartels and monopolies when conceived as furthering national strategic interests (Dobbin 1993). The banking system was reformed by the Roosevelt administration. The Banking Acts of 1933 and 1935 sought to protect banks. In 1933 the Federal Deposit Insurance Corporation was created, and commercial and investment banks were separated. The Glass-Steagall Act of 1933 established Regulation Q, which put a ceiling on interest rates paid on savings accounts and a zero-interest rate for checking accounts. These measures constituted a subsidy granted by the government to the banking industry (Bingham and Sharpe 1998).

During the 1930s the US government also intervened in the airline industry, which developed to support the postal service. Congress authorized the privatization of airmail service in 1925, which resulted in the private sector growing and dominating the industry. While initially the government paid carriers based on the amount of mail delivered, in 1930 it began to pay based on the size of the plane and its ability to carry passengers. This created an incentive for airlines to develop passenger services, increasing demand for new and larger aircraft. Innovation was fostered in both the aircraft and the airline industry (Bingham and Sharpe 1998).

All in all, Roosevelt's New Deal intervened deeply in the national industrial system, in the economy, and in society, seeking to balance the interests of industry, social stability, prosperity, and democracy (Shonfield 1965; Stein 1998).

During the latter half of the 1930s President Roosevelt turned his attention to reorganizing the American economy and preparing for the impending next World War. In a few years, the whole domestic industrial sector was converted to meet military needs. The government architecture from World War I was recharged and strengthened with the creation of the War Industries Board (WIB), the Naval Consulting Board, and the Council of National Defense.

In 1940, President Roosevelt formed the National Defense Advisory Commission Board; in 1941 it was replaced by the Office of Production Mobilization (later renamed War Production Board).This, in conjunction with the Production Executive Committee and the Office of War Mobilization, involved government officials, military leaders, and managers of private industry in converting the national industrial sector to be able to respond to

[1] From 1932 to 1935 the RFC distributed more than $2 billion to companies unable to obtain credit from the private sector (Bingham and Sharpe 1998).

military needs. Foreign suppliers in defense industries were excluded through the Berry Amendment of 1941 (Weiss and Thurbon 2006). The combination of growing public demand for goods and services in the civilian sector and government funds to conduct R&D for military purposes resulted in a significant boost to the development of economies of scale and learning in a selected number of private enterprises (Di Tommaso et al.2019).For yet another decade, American industry was supported by public demand, driven by military needs, and managed by a small group of public officials and a limited number of private managers (Nester 1997;Weiss and Thurbon 2006;DiTommaso and Schweitzer 2013). Producing and fighting were the two imperatives that linked the interests of industry and government.

Since World War I, the military capabilities of the nation have been consistently maintained, with government involvement in the development of weapons, machinery, military technology, and R&D funding – a nearly continuous line assuring the strength of the US military sector.[2]

2.3 "Toward the Great Society": industrial growth, technological advancement, and expansion of socioeconomic opportunities

The end of the war provided new opportunities for future growth. Victory allowed the "frontier" to be moved, guaranteeing further expansion of the market for US industry. Military and political influence over a vast number of nations offered immense economic benefits and extraordinary new opportunities for national industries.

As Di Tommaso et al. (2019) argues, several features of the post-war era could not be removed in a few months or even a few years—support for particular industries, tolerating oligopolies and cartels in strategic sectors, and a public hand in the management of national industries. The Cold War with the Soviet Union further justified a "special relationship" between the government and industry, with substantial industrial and technological implications (both domestically and globally) for American society. The 1945 Vannevar Bush Report highlighted that scientific progress, fed by both basic and applied research, had to be promoted through public programs.

Support for the military played an important role in developing infant industries in the post-war years. The Soviet launch of Sputnik, the first satellite in orbit around the Earth, in 1957 can be seen not only as the decisive boost to fill the perceived technological gap with the Soviets (Weiss 2014), but more broadly as illustrating the close relationship between technological superiority and national defense. To increase technological innovation in the military and civil fields, in 1958 the Advanced Research Projects Agency (ARPA), later renamed the Defense Advanced Research Projects Agency (DARPA), along with the National Aeronautics and Space Administration (NASA) and the Small Business Investment Corporation (SBIC) were established (Block 2008; Fuchs 2010; Weiss 2014). Federal R&D expenditures increased from 1.5 percent to more than 3 percent of US GDP in just a decade (Block 2008; Block and Keller 2011; Mazzucato 2013; Weiss 2014).

Many studies highlight how the rise of the information and communications technology (ICT) industry was based on investments in the military field (Markusen et al. 1991; Abbate 1999; Fong 2001; Mazzucato 2013; Di Tommaso et al. 2019). Growing public demand for computers in the 1950s and 1960s[3] provided incentives for private enterprises to develop new products and new technologies, taking advantage of substantial protection

[2] War times ranged from WWI to the conflicts in Iraq and Afghanistan and included the Cold War (see McNeill 1982 and Weiss 2014).

[3] Commissioned by the United States Department of Defense, Air Force, Army Signal Corps, Atomic Energy Commission, NASA, Weather Bureau (now the National Center for Atmospheric Research), the National Institutes of Health, and Social Security Administration.

from foreign competition. The model of innovation based on start-ups began its development (Mazzucato 2013). A growing number of small businesses, able to create important innovations, began to replace large companies that had formerly been protected (perhaps by barriers to entry facing competing firms); this gave government officials the opportunity to stimulate the private sector through its demand for new technology (Block 2008; Mazzucato 2013).[4]

Development of the Internet goes back to research funded by the US Department of Defense (DoD) in the 1960s.The computerization of military technology at that time tended to concentrate development, production, and presence of equipment in a few strategic areas of the country. This made the nation more vulnerable to missile attacks. DARPA then began funding private partners to develop a network able to connect geographically scattered computers. In 1969, for the first time, two computers located at the University of California, Los Angeles (UCLA) and Stanford University were connected through a telephone line. This was the first step in developing an important infant industry that was publicly protected because of its close links to the national military interests (Abbate 1999; Ceruzzi 2003; Kenney 2003).

Similar patterns shaped the development of nuclear energy[5] used for civilian purposes, whose early stages began after World War II with dedicated research centers and national laboratories. The Atomic Energy Act, which promoted technological advances in nuclear energy production, was approved by President Eisenhower in 1954. In the same year the Power Demonstration Reactor Program was announced by the Atomic Energy Commission. This program, requiring government and industry cooperation, led to the first generation of nuclear reactors for electricity production. Thanks to this favourable investment environment, by 1973 the US had 100 power plants producing electricity through atomic energy (Di Tommaso and Schweitzer 2013).

The fortunes of the biotechnology industry, today one of the most dynamic sectors of the US economy, grew due to actions by the Nixon administration (Hurt 2011).

Due to competitive challenges from abroad, since 1969 the US government has sought to convert the national research program for biological weapons to civilian purposes; the biomedical industry came to be considered strategic for the economy and society. US successes in biotech can be traced back to early research about recombinant DNA, financed by the National Science Foundation and the National Institutes of Health (Hurt 2011; Di Tommaso and Schweitzer 2013).

After World War II, national industry could count on public demand fuelled by the Cold War, on opportunities offered by foreign markets, and on vast domestic demand by the rising middle class. However, the government had to deal with excesses that could threaten growth, as well as structural changes in the economy and society. A large part of America was excluded from the middle class, and people wanted the government to intervene and promote the social goals of economic and social inclusiveness.

President Lyndon Johnson laid the foundations for this with his Great Society. In his new model, government action and industrial policy transformed America by including (at least some of) the many who remained excluded. Federal programs promoting education, health, welfare services, social security, and the fight against poverty were developed (Council of Economic Advisers 1965, 153). They dealt with immediate shortfalls in living

[4] A clear example of the success of this model of innovation is Apple (Mazzucato 2013). For a discussion on the role of the US government in developing computer technology, see Audretsch (1995), Ceruzzi (2003), Adner (2012), and Mazzucato (2013).

[5] At the end of the 1930s, the Manhattan Project funded research for developing the atomic weapons that were dropped on Hiroshima and Nagasaki in 1945.

standards, helped to develop the new workforce that industry needed, and supported consumption spending on private goods.

3. The consolidation of global leadership

3.1 "The government is the problem, not the solution": industrial policy in the neoliberal era

It was during the late 1970s that the term "industrial policy" entered American political discourse, stimulating a polarized debate inside and outside academic circles.[6] President Carter established the Economic Policy Group to design a national industrial policy (Council of Economic Advisers 1981; Bingham and Sharpe 1998). This was never implemented as Carter was not re-elected, and the newly elected President Reagan opposed government intervention in the economy.

The new Republican administration relied on academic literature documenting government failures,[7] and political rhetoric emphasizing the freedom of markets and individual decision-making. They opposed any industrial policy. Instead, the Regan administration looked to protectionist policies to solve structural issues (such as the $114 billion US trade deficit in 1985) and to save jobs (Council of Economic Advisers 1986) in sectors experiencing problems—automotive, textiles and clothing, steel, and semiconductors (Baldwin and Richardson 1987; Niskanen 1988; Richman 1988).

Nonetheless, Reagan didn't hesitate to follow his predecessor and save companies considered "too big to fail." In 1979, Chrysler received $1.5 billion in guaranteed loans, $3.5 billion in additional capital, and concessions from labour unions. After 1981 the entire automotive industry was protected (Graham 1992; Di Tommaso and Schweitzer 2013), as auto imports reached 30 percent of US sales. For instance, a Voluntary Export Restraint negotiated with the Japanese government reduced the number of imported cars from Japan.[8] Similarly, in 1986 the Reagan administration pressured the Japanese government to set a fair market price (determined by the US Department of Commerce) on memory chips. Japan was also pressured to apply the same price in third-country markets to increase sales of American chips there. The Japanese government refused to accept these conditions, and the US imposed a 100 percent tariff on $300 million of Japanese goods (Niskanen 1988; Richman 1988).

The steel sector was protected through restrictions on European exports.

In textile industries, industrial nations adopted the Multi Fiber Agreement to regulate imports through a system of quotas on exports (Niskanen 1988).

Other measures are more focused on protecting and supporting American industry. The DoD, in particular, has played a central role (Reich 1982; Weiss 2014). During the 1980s it actively supported various industries, such as machinery tools and semiconductors, both threatened by foreign competition.[9] Other departments and

[6] See Reich (1982, 1984), Etzioni (1983), Schultze (1983) ,Di Lorenzo (1984) ,Dorn (1984), Dumke (1984), Johnson (1984), Niskanen (1984), Norton (1986), Eisinger (1990), and White (2007).

[7] See Krueger (1990), Le Grand (1991), Chang (1994), Buigues and Sekkat (2009), Di Tommaso and Schweitzer (2013).

[8] The 1982 agreement limited Japanese exports to the US to 1.68 million cars. This limit was gradually increased (Niskanen 1988; Richman 1988; Bingham and Sharpe 1998).

[9] For instance, the National Center for Manufacturing Sciences (NCMS) and the Semiconductor Manufacturing Technology Initiatives (SEMATECH) were set up respectively in 1986 and 1987 for developing new technologies. The latter was supported in 1989 with $100 million allocated by the DoD (Council of Economic Advisers 1989; Irwin and Klenow 1996; Block 2008; Wade 2010).

agencies, such as the Department of Energy, NASA, the National Science Foundation, and the National Institutes of Health, continued to influence technological advances and industrial development.

In this context, technology transfer from government agencies to the private sector became (and remains) a new strategic priority. The University and Small Business Patent Procedures Act of 1980 (known as the Bayh-Dole Act), the Technology Innovation Act of 1980, and the Federal Technology Transfer Act of 1986 introduced several opportunities for technology transfer. It allowed private universities, small businesses, and non-profit institutions to own the patents emanating from government-funded research. Later it extended these rights to private companies of all sizes and public universities and it allowed federal laboratories to cooperate with private companies and retain a portion of the royalties paid to the private sector (Council of Economic Advisers 1989).[10]

Finally, programs were implemented to support the growth of small businesses at the local level. The Small Business Innovation Research program (SBIR), launched in 1982, established a consortium between the Small Business Administration and other government agencies, including the DoD, the Department of Energy, and the Environmental Protection Agency. This program called upon government agencies to set aside a fraction of their research budgets to support initiatives from small private companies. In addition to promoting the development of new start-ups (Lerner 1999;Audretsch 2003; Mazzucato 2013), the program helped create a new innovation system based on a network of institutions and organizations at local, state, and federal levels, able to provide assistance and financial capital to innovative enterprises (Block and Keller 2011; Mazzucato 2013).[11]

The Manufacturing Extension Partnership (MEP), launched in 1988, created state and local government centers providing managerial services and technical assistance to enterprises (Shapira 2001). This helped improve industrial productivity, competitiveness, and the technological ability of small businesses.

3.2 "The end of history": leading and exploiting globalization

The 1990s saw the collapse of the Soviet Union and the end of the Cold War, giving the US a position of global political leadership that was undisputed and considered by many to be definitive (Fukuyama 1992).The US was ready to take advantage of the extraordinary possibilities that the new global scenario offered to the national economy and industry.

In the early 1990s the international political and economic order was changing radically, providing a boost to globalization. Once again there was a possibility of moving the "frontier" and expanding markets. The ability of domestic firms to enter the global networks of suppliers and customers became increasingly important (Gereffi et al. 2005; Pack and Saggi 2006; Gereffi 2014). Economic policy likewise changed in all industrialized economies (Kitson and Michie 1995; Weiss 1997; Buigues and Sekkat 2009; Mügge 2011). Government played a role as regulator of domestic economic activity, by providing public goods to strengthen competitiveness, and at the international level, by setting the rules of international trade.

The Uruguay Round of negotiations that created the World Trade Organization (WTO) in 1994 involved undisputed US political and economic leadership (Panitch and Gindin 2012). Its main goals were reducing both tariff and nontariff trade barriers, regulating foreign investment, protecting intellectual property, regulating

[10] Unsurprisingly ,the number of university patents increased from 230 in 1976 to 900 in 1987 (Council of Economic Advisers 1989).

[11] See also (Whitford 2005), Block (2008), Weiss (2014), Buigues and Sekkat (2009), Schrank and Whitford (2009), Wade (2012), and Di Tommaso and Schweitzer (2013).

previously excluded sectors (such as agriculture and services), adopting uniform quality standards for products, safeguarding each country's labour force, and adopting a system to resolve disputes among member countries (Council of Economic Advisers 1995).

The Uruguay Round also liberalized public procurement markets at the international level, as a result of the WTO Government Procurement Agreement in 1994 (Hoekman and Mavroidis 1997; Trionfetti 2000), although the issue of discrimination against foreign firms in accessing public procurement markets was not really solved. The US gained increased demand for its products, ensured by regulations opening foreign markets and protection of domestic markets thanks to legal loopholes and other informal barriers[12] (Di Tommaso et al. 2019).

Within this scenario, the North American Free Trade Agreement (NAFTA) took a central position. In 1993, the Clinton administration ratified the agreement. NAFTA eliminated most trade (tariff and nontariff) barriers; developed common rules for investment; liberalized sectors like finance, ground transportation, and telecommunication; strengthened labour market and environmental protection laws; created a unified system of intellectual property rights protection; and established a mechanism for resolving disputes (Council of Economic Advisers 1992, 1993, 1995).

The Asia-Pacific Economic Cooperation (APEC) program, established in 1989, aimed at increasing economic cooperation between the US and Asian economies. The Trade Enhancement Initiative, the Andean Trade Preference Initiative, and the Enterprise for the Americas Initiative (EAI) were primarily motivated by the desire of the US government to promote the transition to a market economy in the Soviet bloc countries. Finally, taking into account the worsening of the debt problem in developing countries, the United States actively contributed to promoting institutional reforms and market liberalization in the countries that needed to renegotiate their loans with Western banks (Council of Economic Advisers 1990, 1997; Stiglitz 2002).

Undoubtedly the new "rules of the international economic game" coincided with a period in which the views of the US government and international institutions coincided (Council of Economic Advisers 1995, 212–213). The bargaining power and strategic interests of the US had an almost global reach (Katzenstain 2005; Phillips 2005; Panitch and Gindin 2012).

These new international political and economic conditions increased global stability and enabled the US to reduce military spending. So, something other than defense R&D was needed to promote technological advancement and innovation (Council of Economic Advisers 1991, 1993, 1994). Development of ICT become a priority,[13] one strongly encouraged by the Clinton administration through the Information Technology for the Twenty-First Century Initiative, the Internet Tax Freedom Act, the WTO's Information Technology Agreement, and the WTO's Basic Telecommunications Agreement (Council of Economic Advisers 2000).

A government and private sector partnership was at the center of science and technology policies, such as the National Cooperative Research and Production Act, which further liberalized research cooperation, and the Partnership for a New Generation of Vehicles (PNGV), which sought to develop environmentally friendly technologies for motor vehicles. Funds for research conducted by the National Science Foundation and the

[12] Weiss and Thurbon (2006, 705) contend that "no other state has been as globally active in driving open procurement markets; and no other state has been as nation- ally protectionist in legally mandating 'buy national' policies."

[13] From 1990 to 2000 the contribution of this industry to GDP rose from 5.8 percent to 8.3 percent (Council of Economic Advisers 2001).

National Institutes of Health increased respectively by over 60 percent and 80 percent during the Clinton administration.

Finally, innovation efforts by private firms were encouraged by maintaining tax credits for R&D expenditures (equal to 20 percent in 1999) (Council of Economic Advisers 2001) and by introducing a new system of intellectual property rights protection through the Antitrust Guidelines for the Licensing of Intellectual Property of 1995 (Council of Economic Advisers 1999).

The Clinton administration made arguments that were exactly the opposite of the Reagan administration—government intervention was not destined to fail, but the efficiency of public administration action could be improved. Their approach was that it may be necessary to intervene in national industries in order to benefit the whole society.

Following the approach of Clinton, the WTO Doha Round in 2001 gave President George W. Bush the opportunity to sign several trade agreements that liberalized foreign markets and relieved American businesses from international competition (Ketels 2007).While agriculture was subsidized so it could compete with foreign production (Council of Economic Advisers 2009), tariffs were imposed in strategic industrial sectors, such as textiles, wood, and steel. However, the global geopolitical situation was less favourable to the US and its protectionist approach was challenged (Gallagher 2007). The WTO forced the US to remove the Foreign Sales Corporation, and mounting international pressure led Congress to abolish the Continued Dumping and Subsidy Offset Act in 2007, which provided firms in difficulty with funds obtained from import duties.

A new policy, the American Competitiveness Initiative (ACI), was launched in 2006. It sought to double public investment in R&D over ten years (OSTP 2006; Ketels 2007), but lacked enough support in Congress to be fully implemented (Buigues and Sekkat 2009).

The global financial crisis of 2008 forced George W. Bush to intervene at the end of his second term. The crisis had arisen due to an unexpected and unpredictable collapse of the financial and real estate markets in the United States. The drastic reduction of the value of savings generated a reduction in consumption, and then also in production and finally in investments, thus transforming the financial crisis into a real economy crisis and causing a negative effect on expectations. This chain projected the effects both into the future and especially impacted on the entire world economy like an epidemic (Bianchi, 2014). Government intervention was required to prevent the collapse of the entire banking system. Along with a bailout of numerous banks, the government gave the US Treasury the authority to purchase $700 billion worth of mortgage-backed securities. These actions clashed with Republican rhetoric against government intervention in the economy; however, it was necessary in order to save the US economy, paving the way for the following “rejuvenation of industrial policy” (Stiglitz et al., 2013).

4. “Yes, we can”: crisis, recovery, and new societal goals

4.1 Relaunching the national economy

Barak Obama was elected President in 2008, when the crisis started in the mortgage market in 2007 and spread to the entire financial sector had quickly flooded the real economy leading the United States in 2009 to a fall of 3.1% of the real GDP and to an unemployment rate of 9.3% (ERP, 2013).

In February 2009, at the very beginning of his mandate, Obama signed his first and massive action to recover the US economy, reduce unemployment and promote the American industry: the American Recovery and Reinvestment Act (ARRA), which clearly by-passed the neoliberal rhetoric that had characterized the previous decades. Such "stimulus package" of 787 billion dollars represented "the largest countercyclical fiscal action in American history" (ERP, 2010, p. 52). It not only addressed the immediate economic emergency, it also sought long-term change of the American economy and society (Council of Economic Advisers 2010).

Initially the plan allocated approximately $90 billion for short-term "emergencies", by financing health insurances, unemployment-support initiatives and basic assistance programmes, including, for example, the Supplemental Nutritional Assistance Program. Furthermore, about a third of the budget of the Act was made available also in the form of tax cuts to households and businesses (Tassinari, 2019). Finally, approximately one-third of the total resources were devoted to particular segments of the economy by promoting a long-term development of sectors and industries considered to be "strategic" for the country, such as the financial sector, strategic industries, ICT, and broadband. It also included actions in the fields of education and lifelong learning, science and technology, trade policy, and regional and small businesses development (Council of Economic Advisers 2010; Di Tommaso and Schweitzer 2013; Tassinari, 2019).

The financial sector was the driving force of the 2008 economic crisis and its conformation explains the surprising speed through which the crisis was able to spread from the US mortgage market to the global real economy (Tassinari, 2019). Therefore, the Obama administration followed George W. Bush in intervening to prevent the collapse of the entire banking system, through the bailout of numerous banks. In particular, the financial sector was supported through the Financial Stability Plan added liquidity to the banking system by allocating $2 trillion to buy mortgages from banks. These measures, however, had only a limited effect. Banks were reluctant to lend because of pessimism over the economy, and unable to lend until they built up their capital.[14]

The automotive industry also got bailed out and the sector was one of the main subjects of the government "thought-fulness" (Tassinari, 2019). The Temporary Asset Relief Program (TARP) allocated $17.4 billion to GM and Chrysler, both at risk of bankruptcy and considered "*too big to fail*" due to their relevance in terms of employment, stakeholders and weight in the economy. The US government became the largest owner of GM, acquiring most of its assets. The Obama administration sought an immediate change to the managerial practices leading to GM's economic plight.

The Obama intervention with the greatest visibility concerned health care. In 2010 Congress approved the Affordable Care Act (ACA, also known as "Obamacare"), and the Health Care and Education Reconciliation Act. These bills sought to extend health insurance coverage (by making it mandatory for most employers and individuals). The reform was expected to increase demand for health insurance, stimulating the insurance sector and health care industry. The ACA also sought to reduce health care costs as well as insurance costs, thanks to greater risk-sharing.[15]

Modernizing the energy sector and developing "green" industries were distinctive features of Obama's industrial vision. He sought to reduce US dependence on foreign oil, improve energy efficiency, create quality green jobs,

[14] The administration also sought financial regulatory reform to promote future stability. The 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act established the Financial Stability Oversight Council, which was responsible for monitoring the stability of the financial system. However, it didn't get the more radical reforms it wanted (see Di Tommaso and Schweitzer 2013).

[15] For more details on the ACA, see Di Tommaso and Schweitzer (2005, 2010, 2013).

and reduce pollution. $23 billion was devoted to investment in renewable energy (solar, wind, and geothermal); $16 billion to plug-in hybrid vehicles, electric vehicles, and related infrastructure; and $300 million to purchasing energy-efficient vehicles produced in the United States; $4 billion to constructing a modern "smart grid" to reduce national consumption of electrical energy; and $400 million to establishing the Advanced Research Projects Agency—Energy (ARPA-E) to conduct scientific research in advanced energy technologies (Council of Economic Advisers 2010; Di Tommaso and Schweitzer 2013).

Similarly, in the context of the strategic response to the crisis, a strong intervention on ICT by the Obama administration – i.e. the National Broadband Plan of 2010 – was aimed at expanding the coverage and quality of Internet connections through a strong public investment in broadband.

The enhancement of science and technology, together with education and basic research, was also included in the ARRA, with a budget of about $100 billion (Council of Economic Advisers 2010). This fostered the creation and commercialization of innovative products by supporting start-ups and protecting intellectual property rights (Council of Economic Advisers 2012).

In trade policy, the Obama administration wanted to strengthen international rules to protect and promote the American economy. Indeed, one of the main effects of the crisis at an international level has been to encourage a sort of global reorganization process that calls, to some extent, for a redefinition of the global trade equilibrium. During its first term, the administration took legal action in the WTO to remove barriers constraining American exports of automotive spare parts to the Chinese market. The final verdict forced China to open up its market. The administration also launched an appeal against subsidies and tax forgiveness by China that reduced production costs for domestic companies.

Regional development and support to small and medium-sized enterprises were also Obama administration priorities. The ARRA allocated about $730 million to the Small Business Administration (SBA) to help small businesses address the financial crisis. Other SBA initiatives to support small business were the Export Market Entry Training Program (EMETP) and the Export Trade Assistance Program (ETAP), both aimed at promoting American exports (Di Tommaso and Schweitzer 2013). Finally, in early 2011, Congress expanded the Small Business Jobs Act, providing $2 billion of new tax incentives for new businesses and start-ups (Di Tommaso and Schweitzer 2013).

Finally, the 2010 budget allocated $50 million (Regional Planning and Matching Grants) to improve living conditions in economically backward areas and a 2010 program in the Department of Labour subsidized job training for the long-term unemployed (Di Tommaso and Schweitzer 2013). This included interventions for the maintenance of houses, for the infrastructure for drinking water, unemployment benefits, scholarships for low-income students and students with disabilities, among others.

All in all, the industrial policy approach of the Obama administration was to address problems raised, in the short term, by the crisis, as well as to restore an effective American industrial strategy by tackling the more structural issues that were questioning the US global leadership. Such "interventionist" approach was based on the definition of clear priorities, the selection of strategic industrial targets able to address them and a vision concerning the future of the American industrial system to promote a more sustainable structural change (Tassinari, 2019).

4.2 Expanding economic opportunities

During his second term in office, Obama focused on three challenges— reducing long-term unemployment, expanding the potential of the labour force, and reducing social inequalities (Council of Economic Advisers 2014). The Opportunity, Growth and Security Initiative (OGSI) (Council of Economic Advisers 2014) allocated $56 billion to be shared by civilian and military areas. The money supported policies in education and work training, basic health research, applied research in energy efficiency and renewable energy (including electric motors, batteries, and ultralight materials for electric vehicles), modernization of state electricity grids, a national network of 45 new centres for manufacturing innovation, modernization of the national aviation system, and improved public sector efficiency.

Regarding science and technology, the Obama administration emphasized research addressing new industrial and social challenges. The 2015 federal budget included $135 billion for research (a 1.2 percent increase compared to 2014), with $2.2 billion for advanced manufacturing, $325 million for the transition to clean energy, $2.5 billion for the United States Global Change Research Program, $30.2 billion for the National Institutes of Health (including research against cancer and Alzheimer's disease), and $7.3 billion for the National Science Foundation (Di Tommaso et al. 2019).

Finally, the Obama administration worked to expand international markets by promoting trade and investment with Europe and Asia. The Trade Facilitation Agreement within the WTO aimed at speeding up the movement of goods and services by increasing customs cooperation, and standardizing import and export procedures. The administration also pushed the Trans-Pacific Partnership Agreement (TPP), which included 12 countries in Asia, and the Transatlantic Trade and Investment Partnership (TTIP) with the European Union (Council of Economic Advisers 2014). These regional trade initiatives were designed to give the US easier access to markets with a single regulatory framework (Capling and Ravenhill 2011; Fergusson et al. 2013; Williams 2013).

5. "Make America Great Again": rhetoric and policies

5.1 Selling a hybrid policy approach and building consensus

The 2016 US presidential campaign was radically disrupted by the participation of tycoon Donald J. Trump, an outsider to the American political system. Trump placed himself at the opposite extreme from Obama, promoting a populist rhetoric aimed at delegitimizing the political establishment and its globalization policy. Trump blamed free trade policies as detrimental to the national interest.

After winning the Republican nomination, Trump changed his political discourse by incorporating some traditional Republican positions. However, the real innovation was Trump's attempt to garner white working-class support with an anti-globalization and neo-protectionist rhetoric and blaming the Democratic Party for having lost industrial jobs.

Trump's presidential campaign was something unique in American political history. A first distinctive element was his simplifying the rhetorical discourse by using Twitter.[16] His economic agenda favoured protectionist demands, expressed by a large stratum of the population, over globalization and international agreements. Trump's two main slogan – "America First" and "Make America Great Again (MAGA)" – should be seen as appealing to the losers of globalization (Di Tommaso 2017).

Trump's rhetoric during the electoral campaign can be summed up as a hybrid of laissez-faire proposals for the business sector, significant investment in physical infrastructure, and neo-protectionism (Di Tommaso et al. 2019). Cutting the corporate income tax[17] was set forth as a way to enable multinationals to invest in the US and bring back industrial jobs. Concerning infrastructure, Trump promised to more than double the $300 billion that his Democratic rival, Hillary Clinton, planned to spend. He proposed $1 trillion of projects over ten years by offering tax credits to private companies that finance projects and also giving the companies an equity stake in the projects. According to Ross and Navarro (2016), every $200 billion in additional infrastructure spending would create $88 billion in wages for average Americans and increase GDP more than 1 percent.

On trade and industrial policy, Trump promised to "Make Trade Fair Again" and "Bring Manufacturing Jobs Back to America." He blamed protectionism and interventionist policies adopted by China and Mexico. On the campaign trail he committed to withdrawing the US from the TPP (Trans-Pacific Partnership) and from NAFTA. Further, he promised to impose tariffs on goods from countries actively manipulating their currencies to gain a competitive advantage (with China a primary target) and to bring trade cases against China for violating WTO rules and restrictions. The goal of these policies was to trigger a recovery in domestic manufacturing employment. Economic openness to international trade was seen as unfair and damaging to traditional US industries and costing the nation good manufacturing jobs.

Analysing his surprising election, one can see that votes from blue-collar workers were crucial for success, especially in some core places of the industrial Midwest, such as Ohio and Michigan. Trump received massive support among the white lower/middle classes and workers employed in traditional economic sectors. [18]

5.2 Governing and protecting industries (and interests)

The first 24 months of the Trump administration (January 2017 to January 2019) were characterized by a combination of controversial declarations and substantive actions consistent with his electoral campaign. In this regard, according to Di Tommaso et al. (2019, 99),

> the application of *Trump-Economics* has been so far partially constrained by the forces in support of American capitalism, whose financial interests are likely to seek long-term continuity, thus repudiating the radical attacks by the new President on the globalization system that they contributed themselves to shape.

By investigating the initial steps of the new administration, it is possible to highlight some shifts in fiscal and industrial policy.

[16] Between July 21, 2016 (end of the 2016 Republican National Convention) and November 8, 2016 (presidential election), there were 1,374 tweets, with an increase of followers from 9,892,781 to 13,018,832 (source: www.trackalytics.com).
[17] Trump promised to reduce corporate income tax rates from 35 percent to 15 percent.
[18] Edison Research, National Election Poll, November 23, 2016.

It is worth exploring the first, and so far most important, official economic document of the Trump administration, *A New Foundation for American Greatness, Fiscal Year 2018* (Budget of the US Government 2018), followed by *Efficient, Effective, Accountable: An American Budget, Fiscal Year 2019* (Budget of the US Government 2019).

The former report contains a short preface titled "A New Foundation for American Greatness" that summarizes the human cost of economic stagnation. It emphasizes how "horrible trade deals ... have exported American jobs" resulting in "cities and towns devastated by unfair trade policies" (Budget of the US Government 2018, 6). In addition, the report blames burdensome federal regulation, criticizing the growing regulatory state mainly with respect to the environment. Compliance costs for fuel economy and power plant regulations are estimated to be $10 billion per year. Moreover, it attacks burdensome permitting procedures related to infrastructure investment and the highest business taxes in the OECD.

Subsequently, it stresses the need for new job and economic growth policies, and proposes reduced federal spending to achieve this end—in particular, a $3.6 trillion spending reduction over the next 10 years (keeping the debt-to-GDP ratio at 60 percent).Trump would start by repealing Obamacare and substituting Medicaid for it. Then he would reform the US welfare system, which makes the unemployed dependent on public subsidies, and reduce retirement benefits for government employees, which are considered an unsustainable long-term cost. Moreover, simplification of the tax codes and reducing income and business taxes were central to the 2018 United States federal budget (Budget of the US Government 2018, 9–13). Finally, the top budget priority of the new US government is investment in defense, mostly based on discretionary budget authority for the Department of Defense (DoD): it led to a $52 billion increase (as compared to 2017) up to a total of $639 billion, along with the DoD receiving 45.4 percent of total federal R&D funding, especially through the Research, Development, Test, and Evaluation (RDT&E) account of the Pentagon. Overall, Trump aspired to reprioritize federal discretionary spending—increasing national security funds by relying on budget cuts in nondefense spending.

Such fiscal measures would substantially benefit the upper classes, since three-fifths of public spending cuts come from programs assisting individuals with low or middle incomes (Herrera and Friedman 2017). From this perspective, Trump's concrete policy proposals mark a radical departure from his electoral rhetoric, which invoked reconfiguring domestic production in favour of the globalization losers.

The split between rhetoric and practice is a key characteristic of Trump, as is making declarations to shape expectations, the business environment, and American society. Trump used this in three ways to try to bring manufacturing jobs back to the US (Di Tommaso et al. 2019).

First, publicly blaming and threating those manufacturers who move, or plan to move, production abroad. This strategy was already evident during his electoral campaign. For example: "Vast numbers of manufacturing jobs in Pennsylvania have moved to Mexico and other countries. That will end when I win!" (Trump 2016, August 1). This became more explicit during the first months of his administration with regard to car manufacturers:

> General Motors is sending Mexican made model of Chevy Cruze to U.S. car dealers-tax free across border. Make in U.S.A. or pay big border tax!
>
> (Trump 2017, January 3)

> Toyota Motor said will build a new plant in Baja, Mexico, to build Corolla cars for U.S. NO WAY! Build plant in U.S. or pay big border tax.
>
> (Trump 2017, January 5)

Second, gaining support from US manufacturers through announcements, as exemplified by Trump (2017a):

> For decades, the policy of Washington DC on the subject of manufacturing was a policy best summarized in one word: surrender. They surrendered. Under my administration, the era of economic surrender is over, and the rebirth of American industry is beginning.

Similarly, "Almost 500,000 Manufacturing Jobs created since I won the Election. Remember when my opponents were saying that we couldn't create this type of job anymore. Wrong, in fact these are among our best and most important jobs!" (Trump 2018, August 3).

A concrete action plan, the Manufacturing Jobs Initiative, was launched in January 2017. It aimed to get information and perspectives from a diverse range of business leaders on how to put Americans back to work. It was ended by Trump in August 2017 as a form of retaliation after business leaders protested his comments about a white supremacist rally in Charlottesville that led to violence and the death of one woman.

Third, reducing the corporate income tax. Although cut by less than what Trump promised during the campaign, the Senate approved a $1.9 trillion tax cut in December 2017.Trump (2017b) presented it as follows:

> Our plan also lowers the tax on American business from 35 percent all the way down to 21 percent. That's probably the biggest factor in this plan. We've become competitive all over the world. Our companies won't be leaving our country any longer because our tax burden is so high ... These changes alone are estimated to increase average family income by more than $4,000.

Subsequent actions by business leaders were presented to the public as a direct consequence of this tax bill. In the case of Apple:

> I promised that my policies would allow companies like Apple to bring massive amounts of money back to the United States. Great to see Apple follow through as a result of TAX CUTS. Huge win for American workers and the USA!
>
> (Trump 2018, January 17)

The six-month anniversary of the Tax Cuts and Jobs Act provided an occasion to boast about the results of his policies (Trump 2018a):

> The economy is indeed doing well. Six months ago, we unleashed an economic miracle by signing the biggest tax cuts and reforms ... The biggest tax cuts in American history ... Now it's my great honour to welcome you back to the White House to celebrate six months of new jobs, bigger pay checks, and keeping more of your hard-earned money where it belongs, in your pocket or wherever else you want to spend it ... Our country finally has a tax system that is pro-jobs, pro-worker, pro-family, and pro-American ... "Make America Great Again," that's what's happening.

In addition, up to January 2019 Trump had signed two Executive Orders explicitly referring to the traditional Buy American principles in public procurement.

On trade and industrial policy, the neo-protectionist approach of the Trump administration is in line with campaign promises and is based on a combination of bilateral agreements (as opposed to the long-lasting multilateral approach) and concrete actions against main US trade partners. Along with the repeal of TPP in January 2017, signing the United States–Mexico–Canada Agreement (USMCA) in November 2018 is even more illustrative of Trump's approach to trade relations and policy. After having agreed to a preliminary deal with Mexico in August 2018, this was used to convince Canada to sign on (Trump 2018, October 1):

> Late last night, our deadline, we reached a wonderful new Trade Deal with Canada, to be added into the deal already reached with Mexico ... It is a great deal for all three countries, solves the many deficiencies and mistakes in NAFTA, greatly opens markets to our Farmers and Manufacturers, reduce Trade Barriers to the U.S. and will bring all three Great Nations closer together in competition with the rest of the world. The USMCA is a historic transaction!

Two examples illustrate the implementation of neo-protectionist policies.

In January 2018 the US government imposed tariffs on imported residential washing machines and solar cells and modules, after the Office of the United States Trade Representative (USTR) stated that increased foreign imports are a serious injury to domestic manufacturers. In March 2018 the United States imposed a 25 percent *ad valorem* tariff on steel articles imported from all countries, [19] for national security reasons (Lowrey 2017). As is typical with Trump, an initial investigation launched in April 2017 under Section 232 of the 1962 Trade Expansion Act was presented as necessary for industrial and employment reasons: "We're going to use American steel, we're going to use American labour, we are going to come first in all deals" (Trump 2017,April 20).

> Steel is a big problem, I mean, they're dumping steel. Not only China, but others. We're like a dumping ground, okay? They're dumping steel and destroying our steel industry. They've been doing it for decades, and I'm stopping it. It'll stop.
>
> (Trump 2017c)

This proclamation itself was presented with America First rhetoric: "We must protect our country and our workers. Our steel industry is in bad shape. IF YOU DON'T HAVE STEEL,YOU DON'T HAVE A COUNTRY!" (Trump 2018, March 2) and, later, "Not seen in many years, America's steelworkers get a hard-earned raise because of my Administration's policies to help bring back the U.S. steel industry, which is critical to our National Security. I will always protect America and its workers!" (Trump 2018, November 14).

Trade disputes with China clearly deserve some attention. Despite declarations that the two economies were complementary, and of the need for mutually beneficial cooperation, protectionist actions by US and China between January and November 2018 constituted a trade war over agricultural and manufacturing products, as well as over technology and intellectual property.

After Donald Trump and Xi Jingping met during the G20 Summit in Buenos Aires, the trade war was placed on hold for 90 days from early December 2018 to allow for negotiations toward a deal:

[19] The tariffs at first excluded Canada and Mexico but were extended to them through Section 323 Tariff Modifications in May 2018, and then to Turkey in August 2018.

> My meeting in Argentina with President Xi of China was an extraordinary one. Relations with China have taken a BIG leap forward! Very good things will happen. We are dealing from great strength, but China likewise has much to gain if and when a deal is completed. Level the field!"
>
> (Trump 2018, December 3)

These negotiations focused on technology transfer issues, protection and enforcement of intellectual property rights, tariff and nontariff barriers, cyber theft, market-distorting forces (subsidies and state-owned enterprises, according to the United States), as well as other structural issues such as the trade deficit and the role of currencies and currency manipulation.

A mix of optimism and threats characterizes Trump during 90 days of negotiations that had to reach a satisfactory outcome by March 1, 2019, as illustrated by Trump (2018, December 4):

> President Xi and I want this deal to happen, and it probably will. But if not remember I am a Tariff Man. When people or countries come in to raid the great wealth of our Nation, I want them to pay for the privilege of doing so. It will always be the best way to max out our economic power. We are right now taking in $ billions in Tariffs. MAKE AMERICA RICH AGAIN.

In line with the previous sections, it is important to discuss the elements characterizing Trump's rhetorical practices concerning the automotive industry.

First, Trump explicitly recognizes its strategic relevance for the US economy, especially through claims, announcements, and meetings: "We have, at this table, the biggest car manufacturers in the world. We're working on how to build more cars in the United States" (Trump 2018b).

Second, since the presidential election Trump has consistently and implicitly incentivized automakers to return jobs to the US. Trump blames car manufacturers who have moved—or were planning to move—production abroad, such as in the GM case:

> Very disappointed with General Motors and their CEO, Mary Barra, for closing plants in Ohio, Michigan and Maryland. Nothing being closed in Mexico & China. The U.S. saved General Motors, and this is the THANKS we get! We are now looking at cutting all @GM subsidies, including for electric cars ... I am here to protect America's Workers!
>
> (Trump 2018, November 27)

On the other hand, he openly rewards companies (e.g., Ford, Fiat-Chrysler, GM, Toyota, Mazda) announcing investments in United States plants:

> It's finally happening—Fiat Chrysler just announced plans to invest $1BILLION in Michigan and Ohio plants, adding 2000 jobs. This after Ford said last week that it will expand in Michigan and U.S. instead of building a BILLION dollar plant in Mexico. Thank you Ford & Fiat C!
>
> (Trump 2017, January 9)

This strategy creates an implicit system of threats, incentives, and rewards for companies to reshore (and even to change previous plans, as in the case of GM and Toyota), without using any traditional policy tool: "It will only get higher. Car companies and others, if they want to do business in our country, have to start making things here again. WIN!" (Trump 2017, January 15).

Third, Trump continuously raised expectations of protectionism. Strong rhetoric via Twitter between March and April 2018 blaming what his administration conceives of as "big trade imbalances" and "stupid trade" with the EU and China, was followed in May 2018 by an official investigation under Section 232 of the Trade Expansion Act of 1962 (as in the case of steel) because the industry's health appears to be threatened by vehicle and parts imports.

The current president continues to focus on the manufacturing sector. Unlike Obama, who wanted to upgrade advanced manufacturing industries, Trump seeks a return to traditional manufacturing sectors that require more workers and fewer skills, such as coal mining, steel, textiles, and cars.

From this perspective, development of the green industry has been downplayed by Trump, in contrast to the strong efforts (and vision) of the previous administration. Several declarations and actions dismantled the system of incentives provided by Obama for reducing carbon emissions and promoting renewable energy—quitting the Paris Agreement on global warming in June 2017; repealing the 2015 Clean Water Rule concerning water resource management in September 2019; changing how the EPA calculates the health risks of air pollution in May 2019, thereby weakening Obama's Clean Power Plan that restricted greenhouse gas emissions; ending Stream Protection and the temporary ban on mining coal; reducing regulations on domestic fossil fuel extraction; and the introduction of incentives to revitalize job creation in oil, gas, and coal production (Vakhshouri 2017; Di Tommaso et al. 2019).

Trump's State of the Union Addresses in 2018 and 2019 explicitly mentioned all the above-mentioned priorities, making a full use of his capacity to raise expectations, shape behaviours, and create incentives and disincentives for economic agents. His rhetoric can be seen as simultaneously fulfilling requests for radical anti-globalization and neo-protectionist change by his political base as well as requests for continuity by the strongest interests of American capitalism.

> Americans fill the world with art and music. They push the bounds of science and discovery. And they forever remind us of what we should never forget: The people dreamed this country. The people built this country. And it is the people who are making America great again.
>
> (Trump 2018c)

> The agenda I will lay out this evening is not a Republican agenda or a Democrat agenda. It's the agenda of the American people ... We must keep America first in our hearts. We must keep freedom alive in our souls.
>
> (Trump 2019)

6. Social trends in the long-, medium- and short- run

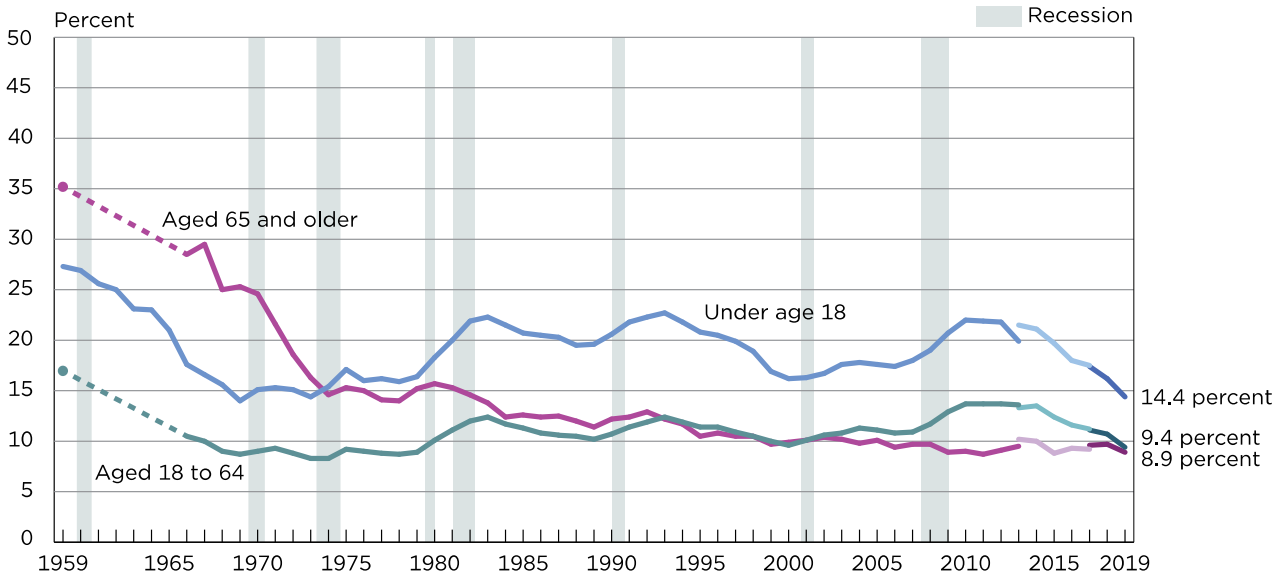
In our view, conceptualizing industrial policy within a social economics perspective requires taking into account both the extent industrial policy is designed and implemented as a leverage for social progress, as well as the extent it is able to make the structural change of the economy socially sustainable.

Focusing on the US case, it is relevant to accompany the historical overview of industrial policies presented in this paper with a look also at available data on social trends in the long, medium and short run, without any

intention of exhaustiveness nor searching for / pointing at any casual relation between industrial policy and social outcomes.

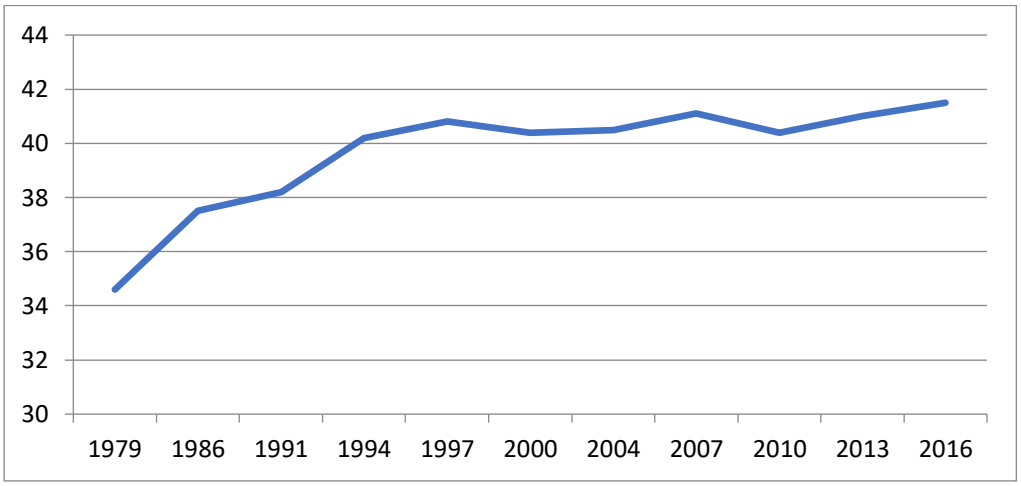
In the long run, the poverty status of people by age[20] 1966-2019 (Figure 1) and the Gini Index[21] 1979-2016 (Figure 2) can be analysed. The former displays substantial improvements for elderly people (with a shrinking percentage below poverty line), while youth and adults age group experience evident fluctuations over the period; the latter shows increasing income inequality in the US over time.

Figure 1. Percent of people below poverty by age group in the US, 1966-2019



Source: U.S. Census Bureau, Current Population Survey, 1960 to 2020 Annual Social and Economic Supplements (CPS ASEC)

Figure 2. Gini Index, 1979-2016



Source: World Bank, Development Research Group[22]

[20] All races together, people as of March of the following year.

[21] Gini index measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution (0 represents perfect equality, while 100 implies perfect inequality).

[22] World Bank data, Development Research Group (Last accessed on 27th October 2020).

In the medium run, it is relevant to look at the Human Development Index[23] 1990-2019 (Table 1), whose value increased from 0.865 to 0.926, an increase of 7.1 percent. However, its increase substantially slowed down in the past decade (1.1 percent between 2010-2019), as compared to the previous decades (2.4 percent between 1990-2010 and 3.4 percent between 2000-2010).

Table 1. US Human Development Index (HDI), 1990-2019

	1990	*1995*	*2000*	*2005*	*2010*	*2015*	*2016*	*2017*	*2018*	*2019*
Life expectancy at birth	75.2	76.1	76.8	77.7	78.7	78.9	78.9	78.9	78.9	78.9
Expected years of schooling	15.4	16.0	15.1	15.7	16.2	16.2	16.3	16.3	16.3	16.3
Mean years of schooling	12.3	12.7	12.7	12.8	13.3	13.3	13.4	13.4	13.4	13.4
GNI per capita (2017 PPP$)	40,942	43,472	50,663	55,075	55,421	59,559	60,024	61,019	62,667	63,826
HDI value	**0.865**	**0.883**	**0.886**	**0.900**	**0.916**	**0.921**	**0.922**	**0.924**	**0.925**	**0.926**

Source: http://hdr.undp.org[24]

As shown in Table 1, between 1990 and 2019, United States' life expectancy at birth increased by 3.6 years, mean years of schooling increased by 1.1 years, expected years of schooling increased by 0.9 years, GNI per capita increased by about 55.9 percent.

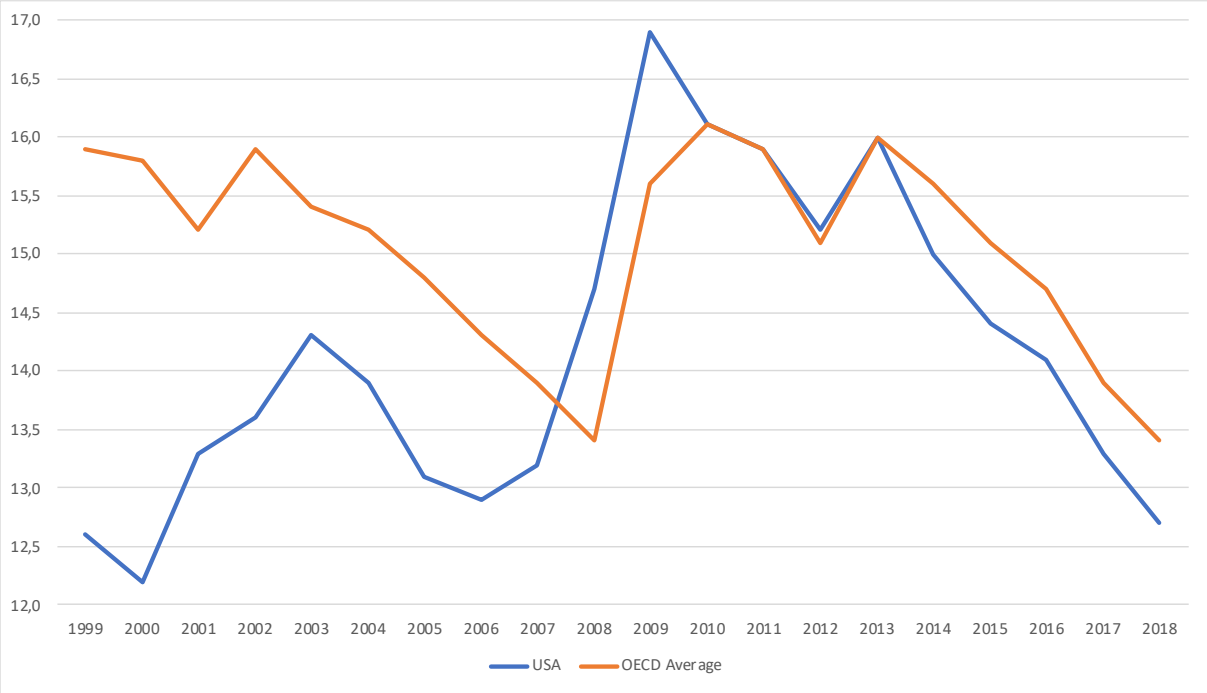
However, it should also be noted that the US lost 9 positions in the global HDI ranking between 2012 and 2019 (from 8th to 17th out of 189 countries and territories) and that its Inequality-Adjusted Human Development Index (IHDI) 2019 was 0.808, with an overall loss by 12.7% due to inequalities in the three dimensions.

Another relevant indicator on social inclusion surely concerns NEET, i.e. young people who are neither in employment (thus either unemployed or inactive) nor involved in education or training, and thus are at risk of becoming socially excluded – individuals with income below the poverty-line and lacking the skills to improve their economic situation. As shown in Figure 3, NEET substantially increased both between 2000-2003 and especially after the financial crisis, reaching the peak of almost 17% (i.e. around one-fifth of total population in the age group) in 2009. Its value is today basically equal to the one in 1999, being still above 12%.

[23] The HDI is a composite index for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living (UNDP, 2018).

[24] United Nations Development Programme - Human Development Reports (last accessed on 13th January 2021).

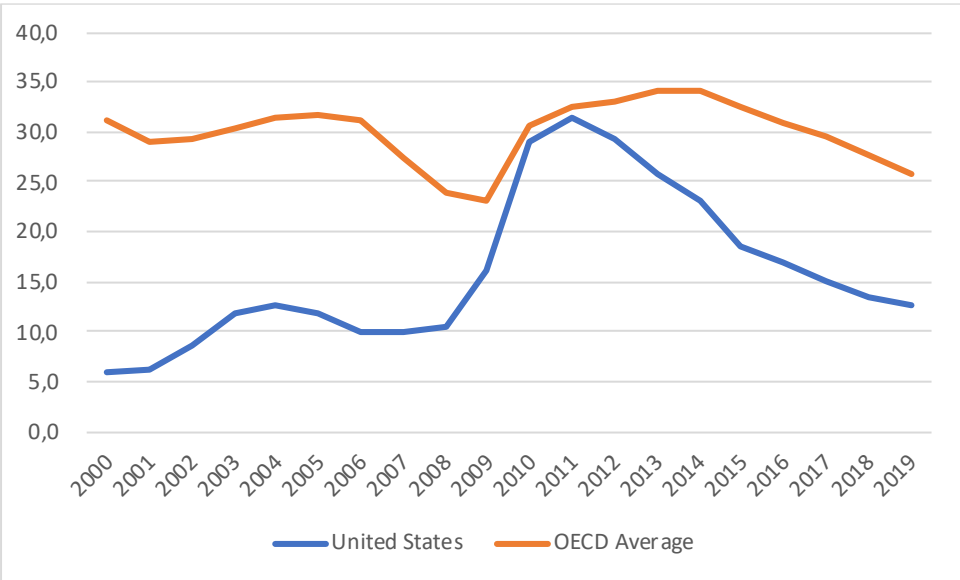
Figure 3. Youth not in employment, education or training (NEET) 15-29 year-olds, % in same age group, 1999-2018



Source: OECD Data[25]

Long-term unemployment is another interesting indicator on socio-economic inclusion. As shown in Figure 4, the incidence of unemployment by 1 year and over among total unemployment for all persons (both men and women, all age groups) has been dramatically growing since 2000 to 2011 (from 5% to above 30%), and it is still today higher than 10% though much lower than OECD average.

Figure 3. Incidence of unemployment by 1 year and over, 2000-2019



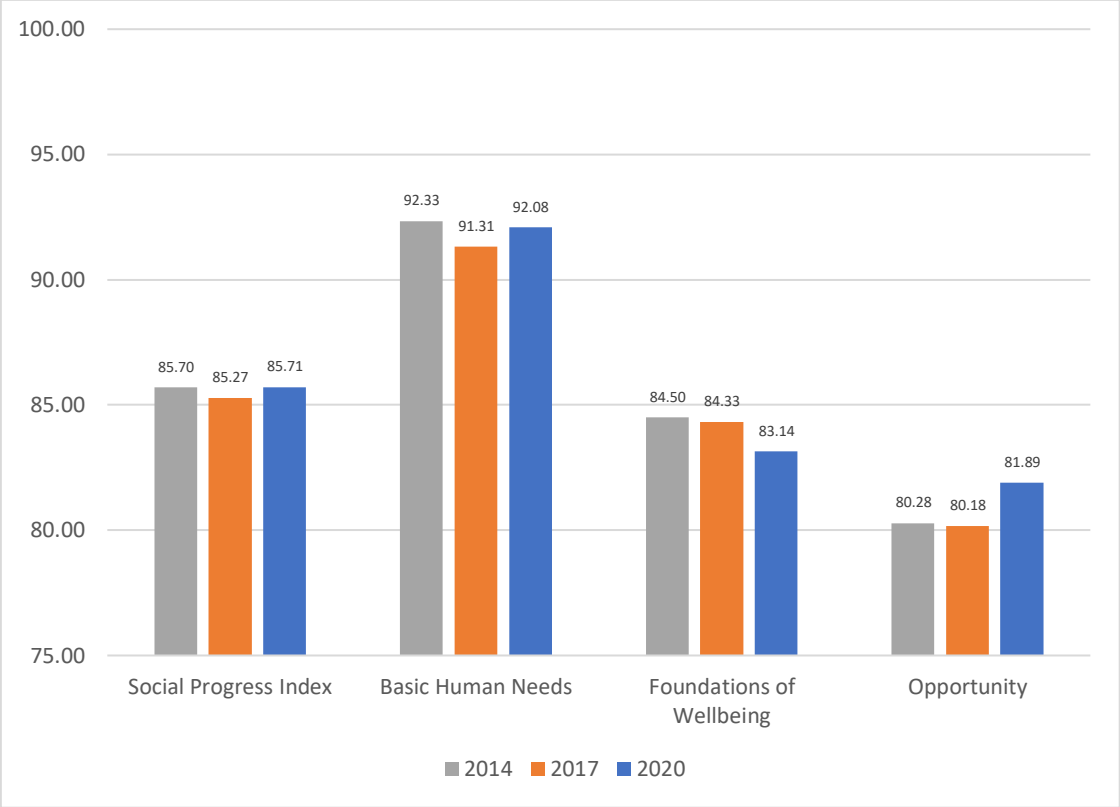
Source: OECD Data[26]

[25] Last accessed on 13th January 2021.
[26] Last accessed on 13th January 2021.

Looking at the most recent years, interesting findings can be derived from the analysis of the Social Progress Index[27] (SPI) 2014-2020 and the Sustainable Development Goals Index[28] 2016-2020.

Figure 5 and Figure 6 show a slight decrease in the SPI and especially in the dimensions of Basic Human Needs and Foundations of Wellbeing. The most significant deterioration has been in Inclusiveness (-7.59), Personal Safety (-5.99), and Personal Rights (-5.49), and there has also been a decline in Health and Wellness (-0.69) (Social Progress Imperative, 2020). Nowadays, its relative weakest components[29] appear to be on environmental quality, personal safety, health and wellness, and access to basic knowledge, while the US main strength lies in the access to advanced education. Overall, the United States is an outlier amongst its peers, being one of only three countries that has seen a decline in social progress since 2011.

Figure 5. US Social Progress Index, 2014-2017-2020



Source: http://www.socialprogress.org[30]

[27] The Social Progress Index – computed by Social Progress Imperative – measures 51 social and environmental indicators to create a clearer picture of what life is really like for everyday people. These indicators across three broad dimensions of social progress: Basic Human Needs, Foundations of Wellbeing, and Opportunity.

[28] The SDG Index represents a yearly assessment of countries' distance to achieving the Sustainable Development Goals (Sachs et al., 2018; Biggeri et al., 2019).

[29] The Social Progress Imperative computes over-performing and under-performing relative to 15 countries of similar GDP per capita, i.e. for the US: Saudi Arabia, Switzerland, Ireland, Netherlands, Denmark, Sweden, Austria, Germany, Australia, Iceland, Canada, Norway, Belgium, Oman, United Arab Emirates.

[30] Social Progress Imperative – Social Progress (Last accessed on 27th October 2020).

Figure 6. Change in US Social Progress Index 2011-2020

Source: Social Progress Imperative (2020, p. 14)

In relative terms, today the US ranks 28th among 163 countries (below Greece and Singapore) in the Social Progress Index: it has lost 8 positions compared to 2014 and it is the lowest of the G7. Moreover, since 2014, the United States has consistently shown underperformance relative to its GDP per capita. On Access to Basic Knowledge, the US performs worse than Cuba and Uzbekistan, while on Health and Wellness the US score is comparable to Albania's. On Personal Safety, the US ranks below Senegal and Sri Lanka (Social Progress Imperative, 2020).

Concerning sustainable development, it should be recalled that the Agenda 2030 for Sustainable Development adopted by the United Nations in 2015 (UN, 2015)[31] dedicates specific attention to SDG#8 on decent work and economic growth (especially through full and productive employment and decent work for all) as well as to SDG#9 on sustainable industrialization, conceived as the primary driver in fighting poverty and preventing social polarization (especially through the integration of small-scale industrial and other enterprises into value chains and markets).

The overall SDG index score for the US computed by Sachs et al. (2020) was 76.43 in 2020 (lower than the regional average score of 77.3), gradually increasing from 72.7 in 2016, while its global ranking decreased from 25th to 31th in the last four years.

In the last year, the best trend on SDG achievement was on SDG#6 "Clean water and sanitation", SDG#8 "Decent work and economic growth", SDG#9 "Industry, Innovation and Infrastructure" and SDG#11 "Sustainable cities and communities", while the worst trend concerns SDG#15 "Life on Land". Similarly, today major challenges

[31] It represents the new universal global Agenda composed by 17 Sustainable Development Goals (SDGs) and 169 targets aiming to balance the three dimensions of sustainable development: economic, social and environmental.

remain on SDG#2 “Zero hunger”, SDG#10 “Reduced inequalities”, SDG#12 “Responsible production and consumption”, SDG#13 “Climate change”, SDG#16 “Peace, justice and strong institutions”, SDG#17 “Partnerships for the Goals”.

7. Final remarks

In the long-run experience of American industrialization and across the historical evolution of the relation between economy and society, has the federal government effectively played an active role? The analysis we have carried out, merging the disciplines of economics, political science, and economic history, aims to contribute to the study of contemporary policy choices by focusing on the industrial policy practices. We have shown, and under what circumstances, and in what way, the federal government has intervened in the domestic economy, and we have discussed to what extent different administrations – despite deploying different systems of societal values – have similarly promoted and sustained an American model of industrialization, economy and society.

Since the days of Hamilton and American independence, the government in Washington has played a central role in America’s economic growth and the process of industrial upgrading. This role has been actively exercised in many historical moments at social, military, and economic turning-points, with surprising continuity until the present day, marked by the current economic crisis.

Since the days of America’s independence, public intervention, in the form that Hamiltonian suggested, has assumed a strategic role of fostering the creation and the development of national economy. From the end of the 18th century up until the first decades of the 21st century, government has been directed to fund, support and protect from foreign competition the American companies operating in sectors considered as strategic, such as railroads, heavy industry, automotive, and – today – high technology. These practices, aimed initially at protecting infant industries, have left their mark throughout the history of America’s industrialization. Naturally, this approach was not unique to the United States, and it is, today, actively pursued in virtually every industrial or industrializing country.

The First World War presented a dramatic opportunity for the consolidation of the US industrial system through the substantial public demand for American products, promoting the development of economies of scale and technological progress. In particular, the intervention of government was encouraged in many areas with military and economic relevance, due to the existence of a 'special relationship' between government and industry based on military and other necessities that continued over the following decades. The era started when technological and industrial progress was fed by an important public military demand, which created a rationale for protection of a number of industries from foreign competition.

During the Great Depression of the '30s, the Roosevelt administration had to further enhance the action of the government in order to address the economic and social emergency. Huge public work programs were financed and with the Buy American Act of 1933 the relationship between the government and the industrial system became increasingly close. In these years there were also several industrial bailouts, in particular in the banking and agricultural sectors. It is interesting to note that many of these actions are seen to reappear in the current debate pertaining to the contemporary financial crisis. Thus, even corporate bailout policies are not an exception

in the American industrial history, but rather represent a surprisingly frequent practice.

From the second half of the 1930s government intervention in the domestic industry was again marked by military necessities. To prepare the country for the Second World War, much of the industrial system came under the public direction and was oriented to meet the growing demand for weapons, vehicles, machinery, services, and technologies needed to support the conflict. The 'special relationship' between government and industry was further strengthened, achieving a scale and intensity never achieved in the past.

At the end of the war, the United States' commitment to maintaining military global leadership, led by the Cold War and the sequence of military conflicts – which are continuing in different forms and locations today – justify the government's intervention in industry, becoming a *de facto* structural feature. The role of the Department of Defense in the industrial and technological development has become stable and continuous, protecting and promoting economic areas of great importance such as semiconductors, software and computer, telecommunications, nuclear energy and biotechnology.

From the 1980s the changes in the international scenario and the progressive acceleration of the globalization processes opened up new areas of action in which the government-industry relationship was intended in some way to address. *Reaganomics* at the national level and the *Washington Consensus* in the international arena became the dominant paradigms. The political rhetoric argued that it was necessary to reduce any government interference in the economic dynamics. These were years of deregulation but, in singular continuity with the past, there were several cases in which the government supported particular firms and industries. In these years, also the advancement of science and technology remained a high priority of the government, with new public programs in particular in the field of ICT. However, beyond the rhetoric, the actual policy was another. Government's ability to promote domestic industry through international negotiations and trade agreements became a central feature of US industrial policy.

With the economic crisis in 2008, the American government was called upon to intervene due to the new dramatic economic circumstances. It was an instinctive action to address the emergencies, and the Obama Administration quickly used many of the tools that had characterized the past American history: bail-outs, public works, stimulus packages, and 'Buy-American'. The government sought, once again, to substantially stimulate, protect, save, and support companies and sectors considered of national interest; the automotive industry, the financial sector, and infrastructure. Surely, history has repeated itself. And there have been other extraordinary interventions targeted to health system, renewable energy, and telecommunications. All these interventions have surely been driven by *short-term* economic and social necessity, but they can also be seen as attempts to look at the *long run*, trying to promote a strategic change and structural adjustment in the American economy.

On the same line of continuity it is possible to situate *Trumponomics* (Moore and Laffer, 2018), whose first aim is to protect the national industry from the rising external competition in a mutated international context characterized by the emergence of China as a global economic player. Even in the Trump era, the continuity in the special relationship between industry and government cannot be denied and should be emphasized. This is clearly the case for instance of i) the unique attention given to the demand from the military complex, ii) the special relationships with selected industries (e.g. steel, automotive), and iii) investments for infrastructure development.

Nevertheless, the Trump administration has been so far characterized by certain elements of discontinuity

compared to the last thirty years concerning trade and – more broadly – foreign policy, with a recent change in rhetoric that is increasingly accompanied by concrete neo-protectionist slogans and actions.

To conclude, it is clear that American industry has been continuously supported, protected, encouraged and saved by the government throughout the country's history. These periods of need for governmental intervention are as common today as they have been historically. Government today, continues without much hesitation to intervene in the American economy, following the precedent of the past reality, not the rhetoric. What has, perhaps, changed, is that there is now a greater realization that interventions designed for the short run, perhaps with political justification, is likely to fail – at least in the long run. The challenge for today is to find ways to ensure that government intervention is effective and efficient, recognizing that the problem is not *whether* to intervene, but *how.* Today's industrial policy needs to be led by a clear long-run vision to address economic and societal problems. It is necessary that a transparent *contract* between government, industry, and society be developed within which a need is acknowledged to evaluate public action, communicate its results, and create a collective consensus for a strategy for building a better society.

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PAPER 4: INDUSTRY 4.0 POLICY FROM A SOCIO-TECHNICAL PERSPECTIVE: THE CASE OF THE "MITTELSTAND 4.0" INITIATIVE IN GERMANY

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Abstract

Industry 4.0 and policies for its diffusion are widely discussed in the literature, providing theoretical rationales and principles outlining the definition of the political objectives in this field. However, few studies have focused on the analysis of the institutional arrangements and policy instruments that governments could concretely put in place, at various levels of the industrial system, to set the processes behind this socio-technical transition. This paper explores whether and how policy initiatives may embrace a socio-technical understanding of Industry 4.0. For this purpose, through extensive fieldwork, we study the illustrative case of the "Mittelstand 4.0" policy initiative implemented in Germany, which targets the diffusion of Industry 4.0 features among SMEs. The results of our analysis show that the Mittelstand 4.0 initiative appears to have undergone a process of continuous adaptation and gradual upgrading towards a socio-technical approach involving creative adjustments and piecemeal changes to address policy beneficiaries' needs. In particular, this involves (i) nurturing knowledge circulation and absorption, (ii) networking for complementarity, and (iii) multi-level directional coordination. The relevance of the German case in providing useful insights for the design and implementation of Industry 4.0 policies is also discussed.

Keywords

Innovation policy; Industry 4.0; Socio-technical approach; German Mittelstand; SMEs

1. Introduction

The literature on Industry 4.0 has been steadily growing over the last decade. This has reflected a concern of both scholars and policymakers with the capacity of industries to compete in a transformed global market landscape by upgrading their production models through an unprecedented industrial integration of ICT infrastructures and digital technologies, as well as substantial changes in the conventional interactions between humans and machines (see, e.g., Schwab, 2016; De Propris, 2016; Bianchi, 2018). This concern has recently become greater by the outbreak of the COVID-19 emergency (see, e.g., Javaid et al., 2020).

A number of contributors agree upon associating Industry 4.0 with the emergence of a "new manufacturing model" characterized by the adoption of "a host of new technologies changing the organisation of production as well as modes of productions and consumption" (Bailey et al., 2018A, p. 1571). Drawing from the history of the previous three "revolutionary" stages of manufacturing production, whose origins have been traced back to the introductions to the industrial realm of specific groups of technologies (conventionally, the steam engine, electricity and chemicals, and ICT and automation for the first, second and third industrial revolutions, respectively) (Rifkin, 2013), the early literature has linked the fourth revolutionary stage of manufacturing production to the industrial usage, either in isolation or combined, of modern and digital technologies, such as cyber-physical systems, augmented reality, Internet of Things, cloud, cyber-security, big data and analytics, on-line platforms but also artificial intelligence, 3D printing and horizontal/vertical integration (Schwab, 2016, p. 7; Bianchi and Labory, 2018). The economic potential derived from the industrial exploitation of these novel technologies has been deemed so radical and disruptive to be associated with the idea of the advent of a Fourth Industrial Revolution (Schwab, 2016; Bailey et al., 2018A; Bianchi and Labory, 2018), potentially contributing to the structural transformation of the economy and society as a whole (Di Tommaso et el., 2020).

From this perspective, a growing body of literature suggests that Industry 4.0 cannot and should not be reduced to technical aspects, but it is rather "a socio-technical concept in which technological, social and organizational aspects interact" (Beier et al., 2020, p. 12; Davies et al., 2017). This socio-technical nature characterizing Industry 4.0 makes it a complex phenomenon, raising both technical problems and social concerns, whose outcomes are often unknown *a priori* and without easy or univocal solutions.

Given this complexity characterizing the transition towards Industry 4.0, both the academic literature and public institutions have by and large recognized the necessity to implement public policies to influence the rate, direction and deployment of the Fourth Industrial Revolution (see, e.g., Buhr, 2016; Bailey et al., 2018A; Reischauer, 2018; Müller et al., 2018; Grillitsch et al., 2019; EU Parliament, 2015). Following the launch of the German "High-tech Strategy 2020" in 2013, several countries implemented industrial strategies to support their domestic firms' transition towards Industry 4.0, including France ("Industrie du Future"), Italy ("Piano Nazionale Industria 4.0"), Spain ("Industria Conectada 4.0"), and The Netherlands ("Smart Industry") (EU Commission, 2016; OECD, 2017).

Despite government intervention being pivotal to enabling the transition towards the Fourth Industrial Revolution, to our knowledge, only a few empirical studies provided in-depth analyses on the institutional arrangements and mechanisms activated by public policies to support this transition (Mariani and Borghi, 2019). These studies offer important rationales and principles to guide public action (Bailey et al., 2018A; Bianchi and

Labory, 2018; Li, 2018; Reischauer, 2018; Sung, 2018; Culot et al., 2020), although the attempts to explore whether policy solutions and instruments that governments put in place, at various levels of the system, take into account the socio-technical features of Industry 4.0 seem to be limited yet (Butera, 2017).

In this regard, our research question relates to whether and how policy initiatives embrace a socio-technical understanding of Industry 4.0. For this purpose, we study the illustrative case of a policy intervention implemented in Germany, "*Mittelstand 4.0: digital production and work processes*", which targets the diffusion of Industry 4.0 production models among SMEs.[1]

Our choice of a qualitative study is consistent with the instrumental nature of the research (Stake, 2005; Yin, 2017) and the attempt to catch all the nuances of the policy process to answer our policy-relevant "issue question" (Stake, 2005, p. 30).

Our study feeds into the emerging literature on public policy supporting firms' adoption of Industry 4.0's key features and contributes originally to its development in three ways: first, while early studies mostly focus on either the technological aspects of Industry 4.0 or the changing nature of the relationship between firms and customers, this article explores the linkages between policymaking and Industry 4.0 by looking at the latter from a socio-technical angle; second, building upon previous studies that have focused their empirical analysis on manufacturing economies, we have empirically investigated a German policy initiative, providing novel insights that add to early literature findings. Third, our findings are not limited to the German context: our case study offers some policy principles that might guide policymaking to appreciate as well as to address the interdependencies and complementarities among technological, organizational and human elements in designing Industry 4.0 initiatives.

The remainder of the paper is structured as follows: Section 2 frames the academic debate on the Fourth Industrial Revolution from a socio-technical perspective, while Section 3 introduces the materials and methods. Section 4 presents our findings, and then Section 5 discusses the main insights and principles. Section 6 concludes with final remarks and implications for future research.

2. The Fourth Industrial Revolution: a socio-technical transition in the making

In recent times, scholars have increasingly debated whether and to what extent the current technological upgrading of manufacturing production and the new ways of organizing its processes are going to transform workplaces and living environments, ultimately leading to a new production paradigm and reshaping socio-economic life more broadly (Perez, 2015; Pfeiffer, 2016; Bianchi, 2018; De Propris, 2016; Seghezzi, 2017; Schwab, 2016; Barbieri et al., 2019). Indeed, the current technological upgrading of manufacturing production is bringing about new types of players and new types of interactions characterizing value creation processes, creating

[1] According to the German Institute for Research on Small and Medium-sized Enterprises (Institut für Mittelstandsforschung, IfM), the term "Mittelstand" is a peculiarity of German-speaking countries and is mostly synonymous with "family business". It refers to both small and medium enterprises (kleine und mittlere Unternehmen). In particular, Mittelstand indicates companies, often family-owned or controlled, with annual revenues up to €50 million and less than 500 employees.

momentum for disrupting conventional configurations and stimulating new collaborations among multiple actors around niche technologies and emerging markets (Kivimaa et al., 2019; Robinson and Mazzucato, 2019).

In this regard, a growing body of literature seems to converge on a socio-technical understanding of the concept of "Industry 4.0" (Beier et al., 2020) since its distinctive features revolve around a "multi-faceted combination of actors, networks, institutions, artefacts, infrastructure, markets and practices, along with cultural and symbolic views and representations" (Edmondson et al., 2018, p. 2) that coherently intertwine "to fulfil societal functions" (Geels, 2004, p. 900). In other words, the foundational elements of socio-technical systems are the interdependencies and complementarities among actors, institutions and technologies deriving from connections between systems' components, such as infrastructures, production systems and industry structure, as well as regulation as policies (Hughes, 1987; Geels, 2004; 2005). Socio-technical systems are thus the result of complex coordination processes between these components, whose interactions and mutual adaptation must be achieved to let a "socio-technical regime", understood as a set of rules that organizes production activities, emerge and consolidate (Lombardi, 2017).

This is precisely the conceptualization of Industry 4.0 that is de facto emerging within the academic and policy literature. From this perspective, the industrial application of digital technologies is not per se a guarantee of a transition to a new socio-technical regime: industrial systems ought to couple integrated and consistent adjustments in all of their components and dimensions.

According to Beier et al. (2020) and their systemic review of over 50 Industry 4.0-related publications, the most relevant dimensions of a socio-technical understanding of Industry 4.0 relate to a) the effects of or on technical systems and concepts deriving from the adoption of principles and technologies from the Internet of Things (IoT) on the manufacturing industry; b) the effects on business models, structural organization and relationships with customers within enterprises; and c) the effects of as well as on humans both within the workplace and in terms of communication and interaction.

Each dimension of change requires a dedicated discussion.

2.1 Technology

Likewise, to the three previous industrial revolutions, which have been properly associated with a representative technology (e.g., steam engine, electricity and chemicals, ICT and automation) (Rifkin, 2013), the Fourth industrial revolution has been linked in its current stage to the prospective use of embedded digital solutions in production (Geisberger and Broy, 2015). Their added value lies in boosting efficiency via sensible automation (Heng, 2015) and real-time machine-to-machine interaction (Forschungsunion, 2013) driven by cyber-physical systems, the Internet of Things and big data as technological drivers at the process and enterprise levels. Nevertheless, academics' and policymakers' understanding of the technological paradigm associated with the Fourth Industrial Revolution is broader and includes a wider array of complementary modern technologies (e.g., additive manufacturing, green technologies, wearable technologies, cloud computing, robotics, autonomous vehicles, biotech and nanotechnologies) that cut across sectors and whose unprecedented fusion and networking (Andreoni, 2017) enable "smart manufacturing" production (De Propris, 2016).

Therefore, the physical and virtual worlds are merged, and all the components and industrial equipment that make up the supply chain, such as factory floors, production facilities, workers, suppliers and customers, are

interconnected in a so-called cyber-physical system. This combination is expected to allow for manufacturing systems to become more autonomous and flexible so that they can manufacture customized products with comparably little added effort (Beier et al., 2020, p. 10).

2.2 Organization

Technological upgrading for higher added-value economic activities will potentially change the traditional "organizational routines" of enterprises (Andreoni et al., 2017) and their relationships with the market base, catering to broader and more heterogeneous customers demanding a greater variety and higher quality of products (De Backer et al., 2015).

Indeed, flexibility is a key attribute of Industry 4.0, conceived as the capability to adapt to changing requirements by replacing or expanding individual modules (Vogel-Heuser and Hess, 2016), which ought to provide firms with a twofold opportunity for evolving their business models and opening up new strategies for value creation (Bailey et al., 2018A). First, manufacturing organisations targeting mass production will progressively be phased out, leaving room for the emergence of advanced manufacturing capabilities meeting the needs of a more customized and tailored market base (Davies et al., 2017), so-called mass-customization (Salvendy, 2001). Second, smart and connected products will usher in user-oriented, downstream, value-adding services attached to goods, a trend that has been defined as the "servitisation" of manufacturing (Vandermerwe and Rada, 1988). Scholars argue that both phenomena, in addition to the blurring boundaries across sectors, will contribute to the reconfigurations of conventional global value chains and international trade towards the potential restoration of local value chains, the re-shoring of manufacturing (Bailey et al., 2018B) and the vertical and horizontal integration of information across value chains (Corò et al., 2017).

The complexity of this socio-technical transformation will also affect the internal organization of firms, flattening the vertical production hierarchies and centralized factory control systems towards decentralising the decision-making embedded within a holistic management approach (Davies et al., 2017).

Overall, business organization processes based on flexibility and decentralization need to be integrated and allow for a greater service orientation while still being very efficient, building on interconnectedness, reconfigurable and modular systems, and effective communication between producers and consumers as key preconditions (Beier et al., 2020).

2.3 Human

Research addressing the effects of digitization on humans has identified ambivalent trends. Some studies argue that automation and new technologies entering industries will probably contribute to the layoff of low-skilled workers, leading to dramatic or more nuanced consequences depending on the policy that each country will implement to face and compensate for workforce losses (Goos et al., 2014; Arntz et al., 2016; Frey and Osborne, 2017). Other scholars highlight that the complex systemic interaction between humans, machines, digital technologies and new markets will also affect the qualitative dimension of labour. This would challenge the Taylorist principles of the scientific management of the workforce (Magone, 2016) towards fully integrated environments and decentralized decision making that are optimized for maximum efficiency, increased

communication with partners across the value chain and flexible reactions to customer preferences (Beier et al., 2020).

The literature has therefore sought to envision emerging scenarios in workforce organization, highlighting the following likely upcoming trends, among others: i) the intensification of human-machine interactions by applying the technical principles of CPS, the Internet, future-oriented technologies and smart systems; ii) the phasing out of routines and repetitive tasks (e.g., less physical and more mental work) to work within service-oriented organizational models (see, among others, Helmrich et al., 2019; Kurt, 2019); iii) the demand for the up-skilling of employees (e.g., ICT skills, openness, communication and cooperation) coupled with a qualitative shift in employment structure in terms of employees' qualifications, requirements and competencies in an Industry 4.0 context (Wolter et al., 2015); iv) a more active type of human-to-human communication (e.g., at the workplace and with customers) and stronger collaborative systems of communication among physical agents, software agents and human agents through IoT and technology supported by human-machine interaction solutions (Beier et al., 2020); and v) the growing importance of life-long learning practices and on-the-job training (Tiraboschi, 2016). However, Hirsch-Kreinsen (2014) has warned that no "one-size-fits-all" approach to workforce organization will arise from the transition of firms towards the Fourth Industrial Revolution. The expected (and unexpected) consequences for future work will be firm-specific according to the specific technological solutions and business model reconfiguration that best suit company interests and capabilities.

2.4 The socio-technical nature of Industry 4.0 and the case for policy intervention

Overall, the socio-technical transition towards the Fourth Industrial Revolution requires firms to combine – and continuously expand – their dynamic capabilities along these three dimensions of change. Nevertheless, the occurrence of this transition remains uncertain and cannot be taken for granted, being based on "complex, multi-faceted processes, involving long-time frames, multiple actors and often a range of both competing and complementary technologies" (Edmondson et al., 2018, p. 2; Davies et al., 2017). Indeed, as a socio-technical transition, the development of Industry 4.0 is the result of numerous and interdependent mechanisms and processes of transformation that are complex and non-linear, with a plurality of possible trajectories and necessarily unpredictable outcomes (Lombardi, 2017).

Moreover, Bailey et al. (2018A) notice that several interlaced challenges affect enterprises' capability to access, recombine and apply a broad range of information, knowledge and expertise to adopt digital technologies, to implement the most suitable organizational model, and to upgrade the workforce's skills and conditions. In particular, early-stage research on the application of Industry 4.0 technologies across firms has unveiled the complexity of the organizational changes brought about by the technological upgrading of industrial production, which might discourage entrepreneurs and managers from engaging with the digitalization of industrial production (Sony and Naik, 2019).

On the whole, this represents a socio-technical transition occurring at the enterprise and systemic levels and involves the interplay of existing industrial assets, players and their knowledge. Thus, these challenges cannot be addressed in isolation, i.e., they require a cross-regional fertilization of ideas to find collective solutions to common problems faced by companies. In particular, scholars highlight that how the actual implementation of Industry 4.0 will be realised will largely depend on the collaborative efforts and interactional competences

(Howaldt and Beerheide, 2010) that characterise businesses, governments, R&D organizations and universities, as well as intermediary associations, such as labour unions and employer associations. The peculiarities of Industry 4.0 imply that its implementation requires "networked collaboration between differing skill sets and knowledge caches" (Buhr, 2015, p. 11).

In other words, a collective effort to trigger a comprehensive process of change towards a new complex economic paradigm and socio-technical regime requires coherently keeping together all the dimensions of transformation linked to the Fourth Industrial Revolution (Bianchi, 2018). However, this effort may risk a systemic failure if there is insufficient coordination among the system actors (Bianchi, 2018; Robinson and Mazzucato, 2019) belonging to different knowledge and business networks, both at the regional and national levels (Müller et al., 2018).

It follows that it is necessary to reflect carefully on the role and function of the state and government institutions in general (Ferrannini et al., 2021), and particularly in steering the socio-technical transition towards the Fourth Industrial Revolution by promoting and consolidating the transformative factors and conditions at the enterprise and system levels. Indeed, the complexity of this transition and the inherent interdependencies and complementarities among system components urge a systemic and multi-layered policy approach to open new pathways in national and local economies and societies (Lombardi, 2017).

For these reasons, the next section explores this argument with respect to the German case by providing an in-depth analysis of the design and implementation of the "*Mittelstand 4.0: digital production and work processes"* policy initiative in light of a socio-technical understanding of Industry 4.0.

3. Materials and methods

In this section, we describe the methodology upon which this paper is based. First, we discuss the research design and the selection of our case study. Next, we describe the distinctive features of the policy under analysis. We then conclude by discussing the data collection process, as well as the steps of our data analysis.

3.1 Research design and case selection

Qualitative studies excel at explicating processes and related "how" research questions (Langley, 1999). They are deemed especially helpful in investigating poorly understood phenomena (Marshall and Rossman, 1995). In particular, Eisenhardt et al. (2016) contend that qualitative research is most appropriate to examine "grand challenges", i.e., potentially solvable problems featuring intertwined and evolving technical and social interactions (Ferraro et al., 2015), whose outcomes are often unknown *a priori*. Qualitative studies are thus able to reveal effective processes relevant for tackling "grand challenges", coping with the "messiness" of their complexity, and producing actionable insights.

Our research question relates to whether and how policy initiatives embrace a socio-technical understanding of Industry 4.0. We conducted case study research (Yin, 2017; Gioia et al., 2012; Stake, 2005; Eisenhardt et al., 2016) on the German policy initiative *"Mittelstand 4.0: digital production and work processes*", targeting the diffusion of Industry 4.0 solutions among SMEs, to fill the research gap and draw policy insights. Our choice of a qualitative

study is consistent with the instrumental nature of the research (Stake, 2005) and the attempt to catch all the nuances of the policy process to answer our policy-relevant "issue question" (Stake, 2005, p. 30).

We selected this case study since the context of its origin and its distinctive features make it the most appropriate candidate with respect to our research question. For the context, Germany has been a first mover in the field of the industrial usage of digital technologies. Early policy initiatives on Industry 4.0 have been devised and implemented "in a very targeted, coordinated, and structured manner" (EU Parliament, 2016, p. 71). Although other EU Member States have shown strong support and interest in Industry 4.0, "only in a few instances is the programme as comprehensive as in Germany" (ibidem). In particular, the pioneering initiative *Platform Industry 4.0,* launched in 2013,[2] gathers representatives of government, business, trade unions and research institutes tasked with collectively defining a national strategy for promoting the digital transformation of manufacturing in Germany. Stakeholders participating in this project are required to pool their technical expertise to achieve a shared understanding and common standards associated with the key factors related to Industry 4.0, notably, the technological domain (including IT security, legal frameworks, standardization processes, security of networked systems), the organizational realm and the effects on human beings (BMWi, 2019). As for the distinctive features of the policy, *Mittelstand 4.0* is an initiative supporting SMEs in adopting key technological and organizational features associated with Industry 4.0. While large enterprises show adequate resources and technical experience to manage the adoption of Industry 4.0 technologies, Industry 4.0 constitutes an intimidating concept for SMEs. The latter often focus more on daily routines, lacking a long-term business strategy, thus fearing potential detrimental effects of Industry 4.0 on their competitiveness (Müller et al., 2018). In particular, Germany was one of the first countries explicitly tackling the heterogeneous pace of diffusion of digital technologies across the national industrial system, notably the worrisome digital divide emerging between larger companies, start-ups, and SMEs (Stentoft and Brinch, 2020). Moreover, "Mittelstand 4.0" represents one of the major Industry 4.0-related policies devised at the national level: launched in 2015, in 2018, the government coalition agreement committed to enhancing and "*further expanding the existing network of Mittelstand 4.0 competence centers*" (German Coalition's Agreement, March 2018, p. 62) for early policy outcomes, and feedback from the beneficiaries was encouraging and pointed to broadening the scope of the initiative (BMBF and ACATECH, 2019). Finally, the popularity of the policy ensured the availability and accessibility of a wide range of information about its design and implementation. We hence want to investigate whether and how this policy has embraced the socio-technical understanding of Industry 4.0, collectively framed in the context of *Platform Industry 4.0*.

The next section presents the policy initiative in detail.

3.2 Case study description

The initiative "Mittelstand 4.0: Digital Production and Work Processes*"* belongs to "Digital Strategy 2025", the German strategy addressing the digital transformation of the domestic economy. The initiative aims to support German *Mittelstand*, specifically the SME group, to start using Industry 4.0 technologies and digital solutions.

[2] It originates from a cooperation agreement signed by the employers' associations BITKOM, VDMA and ZVEI, accounting for more than 6,000 member companies. This initiative was stimulated by the Federal Government with the aim of initiating a thematic cooperation on Industry 4.0 beyond association boundaries.

The initiative is grounded in early empirical surveys on the state of the art of digital manufacturing in Germany, highlighting that the group of small-medium sized *Mittelstand* was reluctant to engage with the digitization process. In 2016, most SMEs in Germany were still slow adopters of digital technologies: 34.6% of them had a very low digitization level, with only 5.3% having used big-data analytics, compared with almost 10% of SMEs in the EU as a whole (EC, 2018); over 30% of the *Mittelstand* introduced only basic elements of digitization, and a mere 20% showed advanced digital maturity in their operational processes (ZEW, 2016). Moreover, German SME management seems not fully aware of the economic opportunities stemming from the digital transformation of their business; many of them lack high-level managerial vision, computing and planning skills, or even a strategy. In addition, poor interoperability and connections between firms' ICT systems prevent SMEs from benefitting the industrial usage of Industry 4.0 technologies (Stentoft and Brinch, 2020).

The "Mittelstand 4.0" initiative started in 2015 and relies on the creation of 26 competence centres across the country. Competence centres (CCs) are tasked to advise the small-middle *Mittelstand* group on the economic benefits, as well as on the issues related to the usage of Industry 4.0 applications and to support them in developing tailored solutions for business optimization.

A CC is a network of non-market actors (from 4 to 10) experienced in technology development and knowledge transfer activities. In particular, CCs leverage the existing institutional setting and include roughly two categories of partners: 1) research institutions (such as universities and Fraunhofer institutes), where most of the Industry 4.0 applications and technologies are developed and tested; 2) transfer partners (such as chambers of commerce or industry organizations), familiar with the specific SME needs. This ensures an appropriate mix of frontier research, technology transfer experience and expertise in tackling the challenges that SMEs face in expanding their business.

CCs have been selected via public competitions and granted funding in three different temporal waves over the period 2015-2018 (with a total budget of 140 million euros). Eighteen of them present a clear regional focus, serving the federal government's purpose of having at least one CC located in each of the 16 states. Additionally, 8 CCs have been established with a broader national scope and a focus on specific sectors and fields. The latter offer specialized services for very specific industries and handle digitalization challenges that are not addressed by regional CCs. Each selected centre was granted a three-year funding (plus two additional years) of approximately 5-6 million euros. The budget might seem low, but it is appropriate for the technology and knowledge transfer activities funded. In fact, CCs are established using the existing facilities and leveraging the specific competences of the partners, and funding cannot be used to conduct novel R&D activities. Regional CCs exclusively serve SMEs and crafts located in their state of reference and offer them four typologies of services free of charge: i) information and awareness-raising activities; ii) demonstration activities such as visits at smart factories and digitalized production plants, along with access to environments for testing out solutions and applications; iii) training courses and workshops offered to both firm managers and employees; iv) tailored concept development and use-case services fitting SME-specific production cycles to optimize their business.

All regional CCs display cross-thematic and cross-sector focuses. As represented in Table 1, the CCs attempt to offer services addressing technologies and applications that cover all the dimensions of change (technology, organization, human).

Table 1. Thematic and sector focuses of Competence Centres

Location	Thematic Focus			Sector focus	Funding started in
	Technology	Human	Organization		
Berlin	x	x	x	A, C, E, F, M, L, T	2015
Darmstadt	x	x	x	A, C, E, F, M, L, S, T	2015
Dortmund	x		x	A, C, E, F, M, L, S, T	2015
Hannover	x	x	x	C, E, M, L	2015
Kaiserslautern	x	x	x	C, E, M	2015
Augsburg	x	x	x	C, E, M	2017
Chemnitz	x	x	x	C, E, M, L, S	2017
Hamburg	x	x	x	C, E, M, L	2017
Ilmenau		x	x	C, E, S, M	2017
Stuttgart	x	x	x	C, H, M, L	2017
Bremen	x			A, F, M, L	2018
Cottbus				A, C, E, F, M, L, S, T	2018
Lingen	x		x	A, C, E, F, M, T	2018
Magdeburg	x	x	x	A, C, E, F, M, L, S, T	2018
Rostock	x	x		M, S	2018
Saarbrucken		x	x	C, E, M, L, S	2018
Siegen			x	C, E, M	2018
Kiel			x	M	2018

Legend: A: Agriculture & forestry; C: Construction; E: Energy; F: Fishing; H: Health; M: Manufacturing and crafts; L: Logistics (transport & traffic) and mobility; S: Services; T: Trade

Source: Authors based on interviews and factsheets

Finally, an independent national agency acting on behalf of the German Federal Government, WIK GmbH, monitors the implementation of the initiative. Agency data for 2018 report that the knowledge and technology transfer measures implemented by CCs reached more than 60,000 SMEs (involving almost 107,000 employees) and approximately 78,000 employers' associations and chambers (involving almost 167,000 people).

3.3 Data collection

Data come from multiple and complementary sources and have been collected over a six-month period, starting in February 2018. First, desk research was conducted to prepare the fieldwork. We used both primary and secondary sources to retrieve information on the actors involved in the creation of the CCs, amount and duration of funding, targets, and the timeline of the policy. Primary sources include CC newsletters, brochures, videos, press releases, project proposals drafted by the consortium of partners to establish the CC, and fact sheets reporting the distinctive features of each CC (e.g., location, organizations involved in its set-up, services offered by technology, and thematic focus). Secondary sources relate to research reports commissioned by the Federal Government on state-of-the art policy implementation, governmental statements on the initiative, policy documents, and conference proceedings.

Next, fieldwork took place in Germany, specifically in the southwestern metropolitan areas of Stuttgart, Karlsruhe, Mannheim and Kaiserslautern. We conducted eighteen semi-structured interviews, either in person or over the phone, with 9 directors of regional CCs, 6 officers involved in the daily activities of the CCs, 1 participant in an event organized by the CC Stuttgart, and 2 officers of the independent national agency WIK GmbH (see Table 2).

Table 2. Interviews conducted during the fieldwork

#	CC	Position of the interviewee	Date	Medium	Duration
1	CC Siegen	Director of the CC	8.8.2018	Over the phone, taped	25'48''
2	CC Cottbus	Director of the CC	28.6.2018	Over the phone, taped	19'50''
3	CC Augsburg	Director of the CC	6.7.2018	Over the phone, taped	12'54''
4	CC Lingen	Director of the CC	25.6.2018	Via e-mail	
5	CC Hamburg	Director of the CC	26.6.2018	Via e-mail	
6	CC Dortmund	Director of the CC	22.6.2018	Via e-mail	
7	CC Bremen	Director of the CC	22.6.2018	Via e-mail	
8	CC Kaiserslautern	Director of the CC	14.5.2018	In presence, taped	1h 20'15''
9	CC Stuttgart	Director of the CC	16.03.2018	In presence, taped	23'18''
10	CC Stuttgart	Officer at the CC. Employed at the Fraunhofer Institute for Manufacturing Engineering and Automation.	8.5.2018	In presence, taped	1h 28'25''
11	CC Stuttgart	Officer at the CC. Employed at the Fraunhofer Institute for Systems and Innovation Research.	15.3.2018	In presence, taped	21'56''
12	CC Stuttgart	Officer at the CC. Employed at the employer association VDMa, the Mechanical Engineering Industry Association.	29.5.2018	In presence, taped	20'06''
13	CC Stuttgart	Member of the work council of a firm in the goldsmith sector.	27.3.2018	Informal talk at the premises of the CC and later interviewed via e-mail	
14	CC Stuttgart	Officer at the CC. Employed at IHK, the Association of German Chambers of Industry and Commerce.	24.5.2018	In presence, taped	1h 27'07''
15	CC Kaiserslautern	Officer at the CC. Employed at the Institute for Technology and Work.	14.5.2018	In presence, taped	1h 20'15''
16	CC Ilmenau	Officer at the CC. In charge of the Marketing and Communication of the CC.	9.7.2018	Via e-mail	
17	WIK	Officer at WIK GmbH.	9.12.2019	Via e-mail	
18	WIK	Officer at WIK GmbH.		Over the phone, taped	

Source: Authors

The sample of interviewees ensured the full coverage of all the different regional contexts and all CC specializations. The questions focused on: 1) the internal CC organization, actors involved and funding; 2) the nature of the services offered to SMEs, how technology and knowledge transfers activities were carried out, and any practical problems associated with SME adoption of Industry 4.0 technologies and application; 3) any departure from the original goals set and how unforeseen events and requests from SMEs were approached; and 4) relationships with other CCs and with the national government. Interviews were taped with permission and later transcribed.

In addition, we visited the premises of the CCs headquartered in Stuttgart and Kaiserslautern, taking part in the events, showrooms and training sessions organized for managers, employees and trade union members, gaining further insights into how Industry 4.0 was addressed by the regional CCs and perceived by market actors. The repeated interactions with CC personnel and the visits at their premises allowed the authors to access further primary sources and engage in informal talks with participants. Interview bias was limited by controlling for the consistency of answers by each interviewee and among different respondents, as well as by continuous triangulation among the information collected during desk research and fieldwork.

3.4 Data analysis

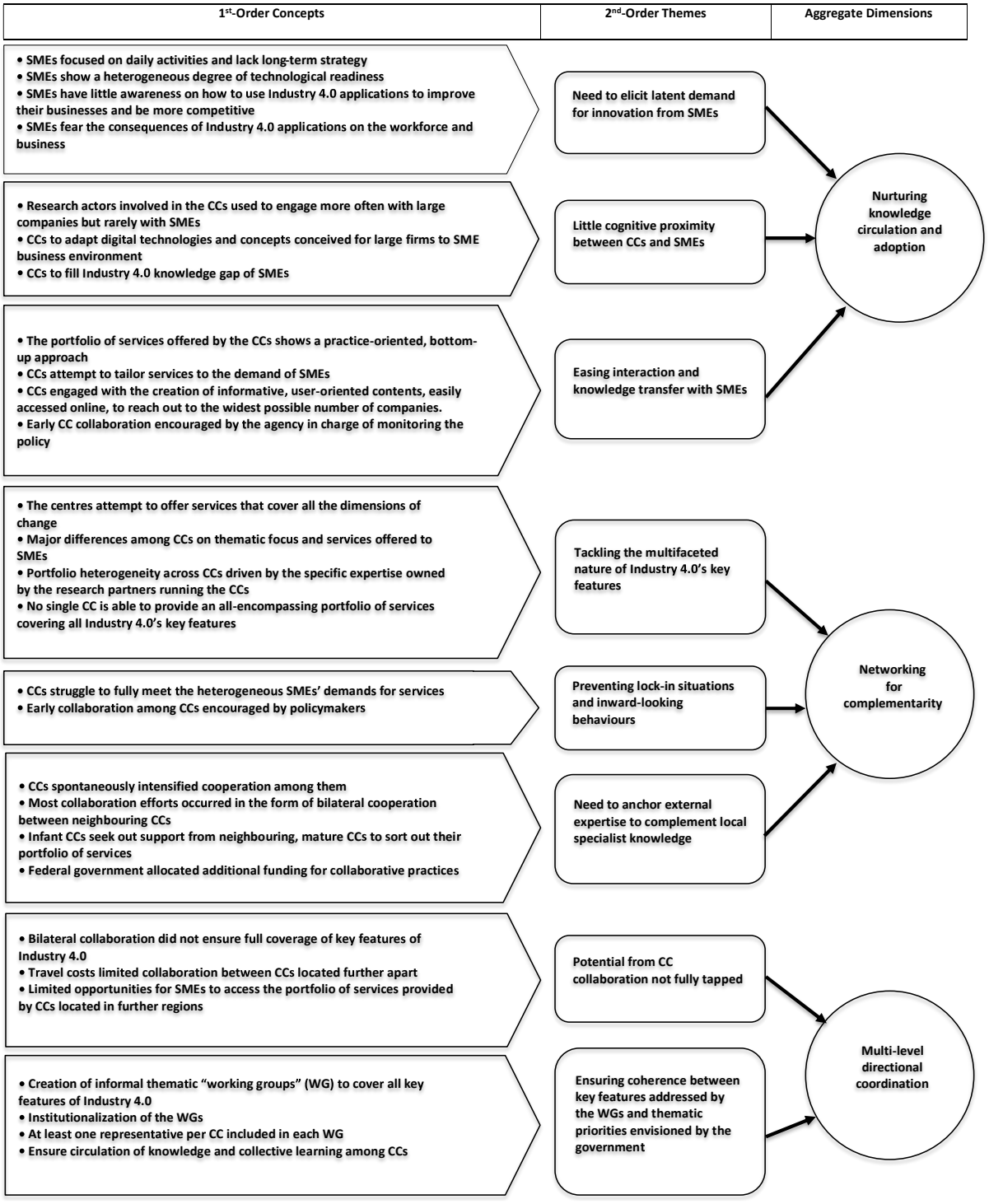
The analysis of the data comprised three main stages. First, we used raw data to organize the case study by chronologically ordering the description of events. Next, we juxtaposed raw data, notably interview transcripts, field notes and primary sources, against each other to ascertain their degree of convergence. In the second stage, raw data were classified to capture the informant's experience in conceptual terms, searching for emerging patterns related to the potential challenges that the CCs might have encountered upon transferring Industry 4.0 key features to SMEs as well as on the prospective solutions provided. Coding proceeded mostly using a lexicon of terms coming from informants, thus grounded in the data (e.g., "SMEs lack long-term strategy", "spontaneously intensified cooperation", "practice-oriented approach", etc.). As the coding proceeded, we were careful to progressively trace the emergence of unexpected challenges and difficulties, as well as the initiatives taken to overcome them and to sort them by type and in chronological order.

In the third stage, we followed Gioia et al. (2012) and engaged with axial coding, i.e., the process of seeking similarities and differences among the many 1st order categories. The analysis proceeded iteratively to hone the emerging patterns and achieve adequate conceptual categories. We then clustered and distilled the nascent 2nd-order conceptual categories into a few key aggregate dimensions. Next, we have built our data structure, making up the appropriate framework that helps us explain the phenomenon we are observing and answer our research question.

4. Findings

This section reports case study findings following the data structure (Figure 1), which includes 1st-order (informant-centric) concepts and 2nd-order (research-centric) themes, eventually distilled into three key aggregate dimensions. We have organized the findings by aggregate dimensions.

Figure 1. Data Structure



Source: Authors based on Gioia et al. (2012)

Nurturing knowledge circulation and absorption

The core services offered to the SMEs by each regional CC revolve around the scientific and technical knowledge produced in-house by their research partners, mostly represented by technical universities along with Fraunhofer institutes, which own the know-how on how to carry out applied research in close cooperation with customers from industry and the public sector.

Therefore, it was not surprising that the CC directors were senior researchers employed in one of these research institutions. The other partners, such as chambers of commerce and industry organizations, were in charge of the marketing efforts, acting as a channel to enter in contact with firms and to attract them to visit the CC premises and access their services. However, interviewees reported that the interaction between the research partners and SMEs, as well as the operations of technology and knowledge transfer, did not occur as smoothly as government officials had prefigured. Indeed, applied research institutes are usually contracted either by larger enterprises seeking advanced technological solutions for boosting their production and business or by large system integrators aimed at jointly developing pre-competitive technologies and concepts, while they rarely interact with SMEs.

The directors of the five CCs set up throughout the first wave of funding (2015-2018) agree that engaging in technology and knowledge transfer activities on digitalization with SMEs was harder than they expected when the CC was set up. They stressed that SMEs have little awareness of how to use Industry 4.0 applications to improve their business and be more competitive since they are mostly focused on daily activities and lack long-term strategies.

Put in the words of the director of the CC Stuttgart, one of the richest in terms of the number and typology of the partners involved:

> "*Adapting advanced digital and production technologies to SMEs is quite complicated, and even more complicated in the case of handcrafts, as technologies generated by researchers like me and my colleagues employed at Fraunhofer's are usually conceived for fitting the production cycles of big companies. They need to be adapted to the technology supports in SMEs, and the latter show a heterogeneous degree of technological readiness*".

In an attempt to ease their interaction with SMEs and raise their awareness of the basic aspects and features of Industry 4.0, the research partners of the CCs have adopted a practice-oriented approach in the forms of user-friendly languages, blended learning formats and customized on-the-job training, drawing from their experience in applied research and technology transfer. All the CCs engaged with the creation of informative, user-oriented content such as webinars, videos, and case studies collected in fact sheets that could have been easily accessed online to ease knowledge transfer and interaction with SMEs.

During the fieldwork, major differences among the CCs on the thematic focus and contents of the delivered services emerged. This heterogeneity was driven, on the one hand, by the specific expertise and equipment of the partners running the CCs and, on the other hand, by the need to tailor services to the demands of the SMEs located in the relevant state. Clearly, SME queries originated from different sectors and branches, reflecting the idiosyncratic economic specialization and sectoral composition of a given state.

Concerning the first driver, differences emerged in particular with "demonstration" services. Since they were mostly offered at the premises of the partners of each CC, the type of service depended upon the equipment owned by the partners themselves. In general, showcases were organized, and SMEs encouraged visiting them and testing out specific technologies and solutions. From our sample, it emerged that only the CCs in Kaiserslautern and Dortmund offered guided tours at a *smart factory*, hence showcasing only to SMEs located in those areas how a fully networked production process works. CCs located in other states offered access to more

limited, although still advanced, services, such as laboratories where test beds and demo factories were made available.

The same is true for training services, whose thematic focus reflected the in-house competences of the CC partners. For instance, several CCs declared offering training on "work 4.0". However, given that the latter topic is complex and multifaceted, the fieldwork uncovered that the CCs were addressing only specific aspects of it, e.g., human resource management and skills upgrading by CC Kaiserslautern, qualification and life-long learning of employees by CC Dortmund, ergonomics and human-machine interactions by CC Saarbrucken and Siegen.

In this regard, the interviewees reported that the work councils and SME employees were particularly sensitive to the consequences of Industry 4.0 applications on the workforce. As an officer of CC Kaiserslautern reported:

> *"We have organized several events, also at the firms' premises, to inform the employees that the use of digital technologies at the shop floors makes the processes more efficient without necessarily firing workers. Rather, it might entail upskilling and new organization of the workforce*".

In the same vein, companies located around Stuttgart, an area where companies are highly unionized, had to face the scepticism of local work councils. Thus, CC Stuttgart expanded its early portfolio of services to include work 4.0 issues and encouraged trade unions from all sectors to participate in events and trainings to have a better grasp on how technologies can reshape employees' tasks.

Along with information, demonstrations and training services, all CCs had to commit to developing tailored Industry 4.0 concepts and use cases for firms, fitting their specific production cycles and aimed at optimizing their businesses. Gradually, these "micro-projects" gained popularity among firms, and their demand intensified across all CCs, for the latter offered to manage the implementation of the concepts free of charge.

Overall, we found that the portfolio of services offered by the CCs and its distinctive practice-oriented approach was particularly helpful to elicit a latent demand for innovation from companies. Informative events, showcases, trainings and projects gathered together multiple stakeholders and triggered bottom-up collaborative activities of knowledge sharing and technology transfer at the local level. This eventually led to unprecedented methods of collaboration between the scientific partners of the CCs and SMEs, as well as among the SMEs themselves.

Networking for complementarity

Since the inception of the initiative, collaboration between CCs has been encouraged by the federal government through a common online platform and through conferences that the CCs had to organize twice during the funding period to publicly disseminate their activities. However, at an early stage, the collaboration among the five CCs set up through the first wave of funding was limited. Although CC partners felt the need to access complementary knowledge to respond to SME queries, they were too far apart to organize joint initiatives, and travel costs were not covered by the budget. Additionally, the partners of incipient CCs were busy building up their portfolio of services, and there was no incentive to exchange expertise among them yet.

Our fieldwork unveiled that later, after the onset of the second wave of CCs in 2016, many CCs spontaneously started to seek out cooperation with each other. For instance, early spontaneous collaboration activities emerged between the partners of CC Kaiserslautern and their neighbouring partners in Darmstadt and Saarbrucken on the topics of human resource management and IT security. Similar collaborations progressively

intensified among all CCs in the form of pooling services to expand their portfolio, mostly with their neighbouring CCs to reduce travel costs.

Physical proximity and complementary expertise on topics of mutual interest represent a recurrent rationale warranting collaboration in most of the interviews. For instance, quoting the director of CC Augsburg:

> "*We started to collaborate with the colleagues of the CCs in Stuttgart, but we have been gradually involved in other activities with the CCs in Chemnitz and Darmstadt. We have found topics of mutual interest and we have complementary knowledge in our respective fields of expertise. Furthermore, the abovementioned CCs are located only a few hours by car from Augsburg. It would be a lot more difficult to cooperate with colleagues located further apart in Germany*".

All of the CCs in our sample declared that they collaborated on a constant basis with other CCs, usually every 4 to 6 weeks, depending on the specific requests put forward by SMEs. Indeed, cooperative activities were driven by the demand for services coming from companies and in the majority of cases occurred in the form of bilateral initiatives of mutual interest, ranging from the joint production of user-friendly factsheets on Industry 4.0 application (e.g., CC Hamburg and CC Hannover on industrial machine retrofitting) to the joint organization of seminars and conferences (e.g., CC Augsburg and CC Stuttgart on production technologies) to the exchange of personnel for events and training sessions (e.g., CC Ilmenau and CC Chemnitz on the topic of IT security). Bilateral cooperation between CCs also came into being as capacity building efforts: CCs set up during the first wave of funding had an advantage on the others in terms of experience, especially on how to engage with SMEs. For example, the incipient centre in Hannover sought support from its neighbouring, mature centre in Kaiserslautern to set up a specific "readiness check procedure" to assess the digital maturity of SMEs and, more generally, to sort out its portfolio of services.

Thus, such cooperation discloses that none of the CCs, not even the richest in terms of number of partners and advanced equipment, is able to offer an all-encompassing portfolio of solutions for Industry 4.0. Our second finding suggests that the practice of anchoring external and complementary knowledge in the form of bilateral collaboration on topics of mutual interest allowed the CCs to avoid lock-in situations and inward-looking behaviours, increasing their capacity to meet firms' demand for services in their respective regions.

Multi-level directional coordination

Our third finding relates to the gradual emergence of spontaneous mechanisms established by the CCs to coordinate their activities. The interviewees unveiled that conferences organized by each CC to publicly disseminate their activities represented an occasion for the directors and officers of all CCs to meet and share their practices, allowing them to learn about activities carried out by more distant CCs with whom they were not collaborating yet.

These spontaneous mechanisms of coordination originated around highly multifaceted topics that bilateral collaboration between neighbouring CCs was not able to fully tackle in their whole complexity, such as workforce organization and upskilling, as well as IT security issues. In particular, informal "working groups" (WGs) self-organized to join forces by pooling resources and exchanging practices in a complementary fashion. At a later stage, as reported by an official from the agency WIK GmbH and confirmed by other interviewees:

"The national independent agency WIK GmbH has encouraged these coordination efforts and the institutionalization of the working groups"

In March 2019, six permanent WGs were formally established as a constituency of the policy: four thematic WGs, namely, "WG Law", "WG IT security", "WG Qualifications, human resource management and Work 4.0", WG "Information and Technology Demonstrations", and two strategic WGs, WG "Marketing", and WG "Leadership". For the four thematic WGs, WIK GmbH encouraged the participation of at least one representative per CC to foster collective learning, transparency and knowledge circulation among them. For the strategic WGs, the WG "Marketing" aims at raising SMEs' awareness of the existence and services provided by the CCs; the WG "Leadership" gathers all the directors of the CCs to ensure alignment among CC practices as well as coherence between such practices and the multidimensional approach to Industry 4.0 collectively devised by "Platform Industry 4.0", which represents the virtual venue where the federal government, representatives of science and business, and trade unions have collectively defined a socio-technical understanding of Industry 4.0 in an attempt to promote the digital transformation of domestic manufacturing in a coordinated and holistic fashion. In particular, through the WGs, the WIK GmbH ensures coherence between the topics addressed by the CCs and the thematic priorities envisioned by Platform 4.0 and by the government in their strategic policy documents on Industry 4.0 (BMBF, 2018)

5. Discussion

Our paper has analysed the case study of the "Mittelstand 4.0" initiative to investigate whether and how Industry 4.0-related policy measures embrace a socio-technical understanding, addressing the interdependencies and complementarities among actors, institutions and technologies.

Our findings have shown that the policy under analysis has pursued its desired outcomes in terms of SMEs' adoption of Industry 4.0's key features by following an adaptive path that policymakers had not prefigured in the early stage of policy design.

First, no CC alone was able to offer a portfolio of services encompassing all of the evolving relationships among socio-technical elements distinguishing Industry 4.0. However, this was not an issue of primary concern for the CCs, which at the beginning had to determine a way to commit to the unprecedented task of transferring advanced technology to SMEs and the craft sectors. Only later did CCs start to realize that their aim to nurture the circulation and absorption of Industry 4.0-related knowledge and technologies among firms did not adequately meet the multifaceted demand and concerns coming from the SMEs. The latter eventually pushed the CCs to join forces and collaborate by pooling their portfolios of services in an attempt to integrate their expertise, initially embracing only a limited number of Industry 4.0 elements, with complementary knowledge sources.

We have shown that such spontaneous departure from the original policy design has helped the CCs remove part of the constraints limiting their ability to tackle the heterogeneous degree of technological readiness and absorptive capacities by SMEs. Particularly, repeated and iterative interactions among CCs over time have

sheltered policy beneficiaries against lock-in circumstances that might have hindered industrial upgrading, as well as increased both CCs' and firms' awareness of the multifaceted and intertwined nature of Industry 4.0's key features. Early collaboration practices and networking mostly occurred among neighbouring CCs when issues of mutual interests were at stake. In addition, the CCs went beyond bilateral, episodic collaboration, creating a few thematic working groups through which channelling their own expertise and sharing the contents of bilateral collaboration activities they have been involved, with the aim of lowering asymmetric information among CCs, increasing transparency and knowledge circulation of the undertaken practices as well as, by means of self-coordination, strengthening the capacity of the network of CCs as a whole to achieve policy goals. The government has approved these piecemeal institutional changes: on the one hand, CCs have been provided with additional funding to carry out such collaboration; on the other hand, the working groups have been institutionalized within the policy. In particular, the latter are considered a fundamental constituent of the policy to ensure multilevel, directional coordination both among the CCs and between the CCs and the socio-technical understanding of Industry 4.0 envisioned by Platform Industry 4.0 as well as the federal government.

Overall, the "Mittelstand 4.0" initiative appears to have undergone a process of continuous adaptation and gradual upgrading towards a socio-technical approach involving creative adjustments and piecemeal changes driven by specific rationales to address policy beneficiaries' needs.

Our case study allows for the development of some policy principles supporting policymaking to appreciate the socio-technical features of Industry 4.0 as well as addressing the interdependencies and complementarities among the technological, organizational and human elements when designing Industry 4.0 initiatives. In general, our findings suggest that policymaking under circumstances of uncertainty requires thinking in terms of processes that will yield the desired outcome.

First, as pointed out by Feldman and Lowe, our results suggest that policy engaging with complex transformation of socio-economic and industrial systems, such as the "Mittelstand 4.0" initiative under analysis, should be conceived as a continuous, iterative and adaptive process rather than a planned and orchestrated intervention (Feldman and Lowe, 2018, p. 348). As we have shown, the adoption of Industry 4.0 applications and solutions by SMEs is not a deterministic or preconceived policy outcome or the result of a plan with a known path forward. The policy has undergone a trajectory change that could not be predicted in advance. Implementation of this policy occurred gradually as a response to the increasing demand and queries from SMEs related to Industry 4.0's features. Hence, the policy is the result of a process that involves participation in networks as well as coordinated actions to maintain a sense of the public purpose of the policy, in this specific regard, the enhancement of domestic industrial competitiveness in global markets. Similarly, given the existence of a plurality of possible directions in socio-technical transitions, the intrinsic uncertainty of the evolutionary scenarios has led to the adoption of a *portfolio approach*: no one-dimensional choices but a set of alternative options, which can generate positive effects potentially excluded from the selection of any single option (Lombardi, 2017).

Second, our findings have unveiled all the limits of addressing a complex phenomenon by decentralizing tasks and responsibilities. Indeed, the search for a policy able to encompass all the key aspects of Industry 4.0 and fully meet the demand, both latent and explicitly expressed by SMEs, has required tapping the expertise of the whole network of CCs. Moreover, preventing the rise of lock-in situations is a necessary condition to accommodating the adoption of Industry 4.0. Therefore, the complexity of Industry 4.0 and the nuanced effects on SMEs have

fostered the need to balance the decentralization of tasks and responsibilities with a mechanism coordinating the operations of the networks at multiple levels to ensure the reach of the desired outcomes. Equally important, when opportunities arose, the government eased their emergence, providing resources and motivating coordinated action from policy constituencies. In other words, multiscalarity from micro-scale to regional and national processes has characterised the evolving and adaptive implementation of the policy.

Third, socio-economic and industrial systems are idiosyncratic by definition, and policy should be shaped according to the demand expressed by local communities as well as to their degree of readiness to embrace the change, which must be nurtured gradually. Our results suggest that policymaking should encourage extant institutional settings and policy constituencies to continuously adapt their missions to face unpredictable challenges arising, as well as to deal with uncertain outcomes. From this perspective, CCs can be understood as *transition intermediaries* (van Lente et al., 2003; Kivimaa et al., 2019), whose role is to interpret the phase of the industrial process lifecycle in the region to drive a socio-technical transition towards Industry 4.0 in all its dimensions. In particular, through a progressive process of access to wider and wider competences involving local and national flows of knowledge and relations, CCs can be regarded as "brokers between multiple priorities, interests and knowledge pools" (Kivimaa et al., 2019, p. 1067) to create momentum for change and new collaborations around technologies, ideas and markets.

To conclude, the early assessment of the "Mittelstand 4.0" initiatives (BMBF and ACATECH, 2019) seems to point to the preliminary effectiveness of these policy principles. Indeed, the firms involved in the CCs' activities and receiving their services evaluate the presence and role of the regional CCs very positively. The most appreciated features are the physical proximity to cutting-edge technologies (due to the regional configuration of the policy), the practical and operational nature of the activities oriented towards the direct application of new solutions, the timeliness and responsiveness of the provided services, and their gratuitous nature. *Mittelstand* appreciates collaboration among CCs because it allows them to access services provided by other regional CCs with different specializations, although this needs to be further improved. The setup of the WGs goes in this direction.

6. Conclusions

Drawing from the case study of the "*Mittelstand 4.0: digital transformation and work process"* initiative, this article has investigated whether and how policy initiatives embrace a socio-technical understanding of Industry 4.0. The research question is a timely one. While early contributions on public policy targeting the diffusion of Industry 4.0 have mostly focused on its technological aspects as well as on the changing nature of the relationships between firms and customers, a growing body of research has recently defined Industry 4.0 as a socio-technical phenomenon (Beier et al., 2020) in which technological, social and organizational aspects are intertwined (Beier et al., 2020, p. 12). This socio-technical nature makes Industry 4.0 a complex phenomenon, raising both technical problems and social concerns, whose outcomes are often unknown *a priori* and are without easy or univocal solutions.

Our research has contributed to the emerging literature on public policy supporting firms' adoption of Industry 4.0's key features by looking at it from a socio-technical angle. Two main conclusions arise from our findings: in

line with the emerging literature, we advocate that it is necessary to take into account the socio-technical features of Industry 4.0 to support policymaking to address the interdependencies and complementarities among the technological, organizational and human elements when designing Industry 4.0 initiatives. Second, policymaking engaging with the complex transformation of socio-economic and industrial systems, whose outcomes are not known *a priori* (as the "Mittelstand 4.0" initiative under analysis has shown), should not be conceived as planned and orchestrated interventions; rather, policy constituencies should continuously adapt their mission to face unpredictable challenges, as well as to deal with uncertain policy outcomes.

The limitations of the study primarily relate to the fact that an evaluation of the outcomes of the "Mittelstand 4.0" initiative in terms of its effects on firms is still missing: assessing the short-term and long-term impacts would require a longer timespan to access an appropriate amount of longitudinal data. In this regard, and concerning future promising avenues for research, it would be useful to keep monitoring the implementation of the initiative and evaluate its impact through mixed methods. Furthermore, comparative studies among Industry 4.0 policy initiatives would prove useful to further expand this line of research and provide additional insights into whether policymakers have obtained a socio-technical understanding of Industry 4.0 and how such policies are being implemented.

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PAPER 5: THE POLITICAL ECONOMY OF PLACES IN A SUSTAINABLE HUMAN DEVELOPMENT PERSPECTIVE: THE CASE OF EMILIA-ROMAGNA

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Abstract

In this article, we discuss how integrated industrial policy can simultaneously pursuing value-added generation and productivity- enhancement in regional economies, along with inclusiveness and social cohesion. Our arguments are rooted in the integration of the literature on human development and capability approach, on economic geography and on industrial policy. In particular, we introduce a people-centred and place-based perspective on Sustainable Human Development and an interpretative political economy framework for the structural analysis of collective action in places. These arguments are illustrated by analysing recent industrial policies for a new social cohesion in the Emilia-Romagna region in Italy.

Keywords

Sustainable Human Development; Place-based approach; Political economy; Capabilities; Industrial policy; Emilia-Romagna

1. Introduction

Nowadays, we are all increasingly aware we are living times of deep structural transformations, urging more sustainable, inclusive and resilient forms of development (OECD, 2020; UN, 2020; WEF 2020). The disrupting effects of the COVID-19 pandemic on our economies and societies have been making evident the weaknesses of our health systems, but also pointing out the limits of our production and social protection systems. Therefore, the social and economic fragmentation affecting vulnerable individuals and marginalised territories appear to be even more deep and alarming than before.

The challenges of the current and future uncertain scenario require the upgrading of productive and dynamic capabilities at firm and industrial level (Fagerberg and Srholec, 2017) to go hand in hand with the expansion of human capabilities (Sen, 1999) and the protection of our natural environment and ecological systems (Goldin, 2014; WCED, 1987). This perspective is in line with the four pillars of the Sustainable Human Development (SHD) paradigm – i.e. productivity equity, participation and sustainability – and with the need to devise policies and strategies to establish 'a fairer, more inclusive, more sustainable and more secure route to global economic development' (Martin et al., 2018, p. 14).

Among them, industrial policies – conceived as government interventions dealing with contemporary production dynamics (Bianchi and Labory 2019A; Di Tommaso and Schweitzer, 2013) – undoubtedly play a central role for the structural change of our economies and societies (Aiginger and Rodrik, 2020; Bailey et al., 2019a; Di Tommaso et al., 2020; Pianta et al., 2016) and for the pursuit of SHD (Ferrannini et al., 2020). Indeed, living conditions, multidimensional wellbeing and human capabilities are deeply influenced by productive industrial performances (Aiginger, 2014; Becattini, 2015; Biggeri, 2020; Sen, 1990). Moreover, as argued by Di Tommaso et al. (2017), the industrial policy practices common to many governments throughout history show how some targets (e.g. sectors, regions, aggregations of entities, firms) can be considered strategic both because they produce economic growth as well as people's quality of life by offering specific merit goods and fundamental capabilities for increasing people's participation in economic and political processes (Sen, 1999), e.g. opportunities for gender equality, empowering women and creating decent employment for the youth (UNIDO, 2015).

According to this conceptualisation, industrial policy does not only aim at correcting market failures and promoting industrial change, but 'it is envisaged as a strategic policy, which is essential to broader economic growth and also to social and civil development' (Bianchi and Labory, 2011, p. 2).

However, any industrial policy is not designed – and does not operate – in a vacuum. Rather, it is shaped by 'the complex nexuses linking structures, institutions and policies in a particular context' (Andreoni et al., 2019, p. 3), thus generating multiple trade-offs and potential conflicts within decision-making processes. Therefore, political economy is required as central type of investigation, in line with its early conceptualization by Robbins as the study of the relationships between growth of the provisions and development of entitlements, namely between the types of growth of economic resources (and types of production organisations) and the modes of institutional development, which guarantee to individuals the right to participate in the economic dynamics and in the growth process (Robbins, 1978, pp. 37-38).

Similar arguments appear especially relevant at regional level, where implicit and explicit power structures and processes directly shape the progressive transition towards more sustainable forms of industrial development –

in economic, social and environmental terms – or the regressive enhancement of social fractures and inequalities along with lagging productivity (Bailey et al., 2019a; OECD, 2018; Pike et al., 2017; Turok et al., 2017).

The objective of this article is to discuss to what extent and how it is possible to design an integrated industrial policy able to simultaneously pursue value-added generation and productivity-enhancement in regional economies, along with inclusiveness and social cohesion.

This article contributes to the literature in three ways.

First, we argue that a normative vision of SHD at the local level based mainly on Amartya Sen's capability approach is necessary to reconcile the twin challenges of combatting exclusion and inequalities and improving productivity and value-added enhancing processes in places.

Second, we stress that nowadays rethinking the political economy of places appears to be especially urgent, as the interplay between economic, social and political processes is pervasive, especially within the industrial policy debate.

Third, we examine the experience of the recent industrial policies in Emilia-Romagna, which has been leveraging on the industrial and economic dynamics for the structural transformation of its regional society.

The article is structured as follows. The second section discusses the perspective of SHD at local level and the renewed role for industrial policies in places to tackle societal challenges. The third section introduces a new place-based political economy framework to analyse the design and implementation of integrated industrial policy. The fourth section analyses the case-study of Emilia-Romagna, discussing both the overall design and implementation of integrated industrial policies for a new social cohesion in recent times, as well as specific reforms and interventions. The last section concludes on lessons learnt and implications for future research.

2. A Sustainable Human Development perspective: reconciling productivity, value-added generation and inclusiveness at local level

2.1 Current challenges and Sustainable Human Development

The concomitance of the decline of productivity growth – both in advanced and emerging economies – along with the backdrop of rising – or persistently high – inequalities of income, wealth and well-being among individuals, social groups and places within countries is a widely debated and worrying issue in academic and policy spheres (Fleurbaey et al., 2018; Martin et al., 2018; OECD, 2018; Piketty, 2014; Sen, 2009).

The advent of a fourth industrial revolution is further complicating the scenario, with the on-going transition towards new ways of structuring production, business models and work organization due to digitalization, big data and artificial intelligence (Bailey et al., 2019b; OECD, 2017; Schwab, 2016).

The current shift towards a new production and manufacturing model thus represents a crucial occasion to rethink and foster an integrated approach for industrial policy design and implementation, in order to holistically pursue the three dimensions of sustainability (i.e. economic, social and environmental), in line with the 2030 Agenda for Sustainable Development (UN, 2015). Indeed, both academic debate and policy evidence have acknowledged the strong and direct interconnection between production systems and processes, well-being and

freedom of people, and dynamics of structural and social change (Aiginger and Rodrik, 2020; Bianchi and Labory, 2019B; Di Tommaso et al., 2020; Ferrannini et al., 2020).

The SHD perspective, grounded on the capability approach (Sen, 1999 and 2009; Nussbaum, 2000), has long and robustly challenged the mainstream development thinking. This approach considers human well-being, participation and freedom to be central economic and social objectives. Therefore, any development process should be pursued or analysed by the point of view of people's capabilities to function, i.e. the opportunities and abilities people have to be and to do what they have reason to value (Sen, 1999), shifting towards a people-centred perspective. It follows that the main policy implication of the capability approach is that social and economic arrangements should aim to expand people's capabilities, i.e. their freedom to promote or achieve valuable beings and doings. At the same time, SHD stresses that human progress springs also through virtuous synergies among positive social outcomes and between these and "positive" economic / productive outcomes (Mehrotra and Biggeri, 2007).

These arguments appear clear in the four pillars of SHD (Haq, 1995): i) Equity, in terms of political, economic, social and cultural opportunities, as well as distribution and cohesion; ii) Participation and empowerment, conceived as being an active individual and collective agent of one's own future; iii) Sustainability, concerning equal intergenerational opportunities in environmental, social and economic terms; and iv) Productivity, pursuing an efficient use of local resources within production systems.

Anyway, positioning human capabilities at the centre of development processes (UNDP, 1990) within a SHD perspective requires illuminating 'the ways in which productive forces shape human relations and are in turn shaped by them' (Bagchi, 2011, p. 34).

2.2 A new conceptual ground

Embracing this perspective and addressing these issues pushes us i) to acknowledge the individual embeddedness within the complexity of systems' dynamics; ii) to embrace linkages and feedback-loops among individual, collective and territorial processes; and, iii) to pave the way for an integrated industrial policy approach.

Hence, each of these points is discussed below to build a new conceptual ground.

2.2.1 Individual embeddedness and multi-layered systems

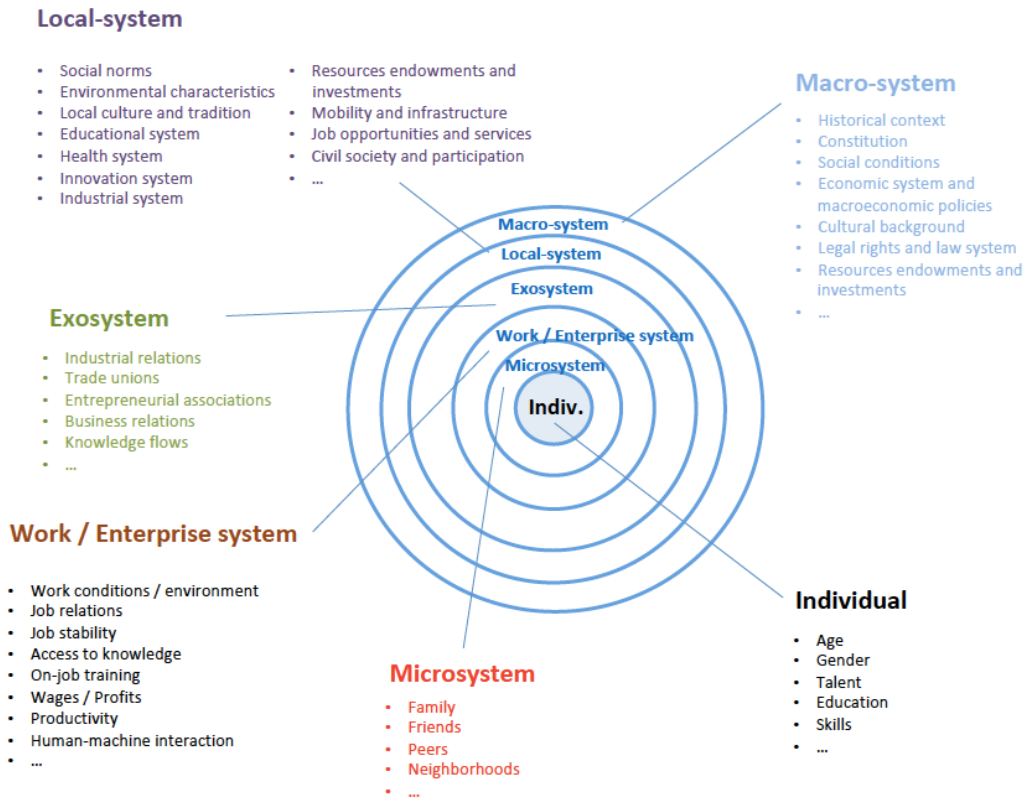
As for the first point, we highlight the need to embrace together the different layers of socio-economic systems shaping human capabilities in which individuals are embedded.

As depicted in Figure 1 by expanding the bio-ecological model proposed by Bronfenbrenner (1979), the individual – with her/his own personal characteristics – is at the centre of the analysis, surrounded by her/his immediate environment, i.e. the "microsystem" (e.g. family, friends and peers, and proximate community). Moreover, each individual – for instance, an entrepreneur or an employee – is part of a specific "work or enterprise system", whose features affect his/her capabilities and well-being. Such system is further embedded in an "exosystem" of linkages and processes taking place in broader settings – e.g. business and industrial relations, knowledge flows, etc. with no specific boundaries – that have an influence on the individual even though she/he does not directly

participate in them. Finally, all these systems are embedded into "local" and "macro" systems characterised by specific endowments, norms and policies. The former – i.e. the "local" system with its territorial functionings – is central in terms of outcomes (e.g. access to goods, services and opportunities to expand human and firms capabilities), because the "working" performances expressed by a local system where people live and firms operate are key resources and conversion factors that give them the opportunity to achieve their objectives and flourishing (Biggeri and Ferrannini, 2014). The latter – i.e. the "macro" system – is the outermost layer comprising economic and historical context, formal institutions, culture and macro-economic policies, thus affecting overall entitlements and rights in social and economic terms.

All in all, these layers of socio-economic relations interact with each other and may have a direct or indirect impact on individual and collective well-being.

Figure 1. The human embeddedness in multi-layered socio-economic systems



Source: Authors based on Bronfenbrenner (1979)

2.2.2 Linkages among individual, collective and territorial processes

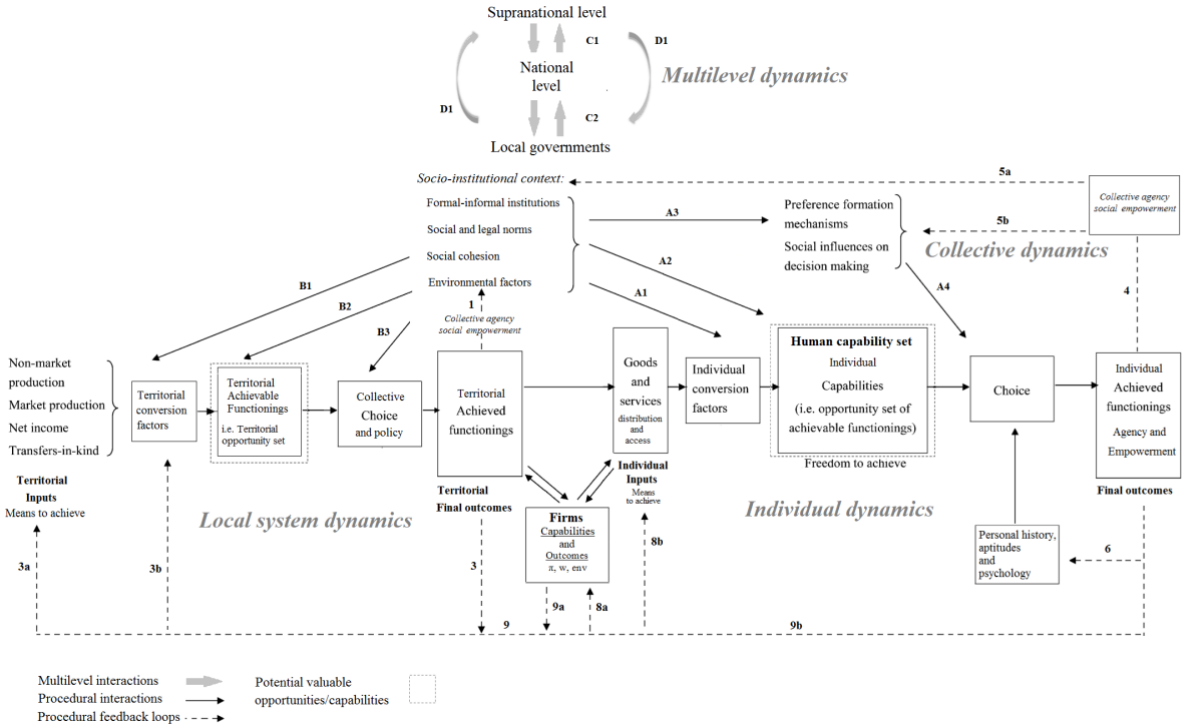
As for the second point, a place-based and people-centred perspective of SHD at the local level is adopted, along with an adjusted version of the STEHD (Sustainable Territorial Evolution for Human Development) framework proposed by Biggeri and Ferrannini (2014) and Biggeri et al. (2018).

This starts from the premise that different places – given their endowments, social capital and relations, institutional features and normative structure, environmental characteristics, etc. – can determine very different outcomes in terms of productive performances, quality of life and lasting prosperity (Barca et al., 2012; Di Cataldo

and Rodríguez-Pose, 2016; Iammarino et al., 2017; Turok et al., 2017). Moreover, these endowments involve a combination of "sedimentary" factors (e.g. institutional, cultural and traditional features deposited and nurtured over time) with "alive" factors (e.g. social or collective learning processes), whose relations of synergy, compensation or hindrance shape the trajectories of SHD at the local level.

The STEHD framework is conceived as multilevel, multidimensional, complex and evolutionary (Biggeri and Ferrannini, 2014) and it is composed by following components (as depicted in Figure 2): (i) the individual dynamics of a person's well-being on the lower right-hand side; (ii) the collective dynamics of agency and empowerment on the upper right-hand side; (iii) the territorial / place dynamics on the left-hand side; (iv) the multilevel dynamics at the top.

Figure 2. The STEHD framework



Source: Authors based on Biggeri and Ferrannini (2014) and Biggeri et al. (2018)

As sketched in the diagram, the local socio-institutional context shapes both the well-being of individuals and firms (Group A of straight lines) by affecting their conversion factors, their capability set and their choice processes, and the internal development path of the place itself (Group B of straight lines). Similarly, the national and supranational levels affect – and are, in turn, affected by – local development processes (Group C and D of straight lines), stressing the potential relations of synergy, hindrance or compensation among governance levels, as well as potential territorial partnerships beyond national boundaries. The evolutionary nature of this framework is represented by the main feedback loops and interactions that occur within and between each analytical component (numbered 1-9), which drives the structural transformation of social, economic, ecological and institutional features at the local level (Biggeri and Ferrannini, 2014).

Two clarifications are worthy at this stage.

Firstly, firms' capabilities are based on the local and extra-local goods, services and knowledge each specific firm has access to, and how these goods, services and knowledge are mediated by firms' internal conversion factors. For instance, each territory achieves specific functionings in terms of business environment, leading to the provision of an array of business services (knowledge diffusion, R&D support, etc.), which a firm, through its conversion factors (e.g. management capacity, workforce skills), can convert into entrepreneurial outcomes.

Secondly, at the firms' level the potential tension between profit-maximizing objectives, wages consolidation, workers' dignity and environmental protection shapes the internal functional distribution, directly and indirectly affecting SHD processes at local level. If local firms view their workforce only as means of production to be exploited and/or they degrade the surrounding environment for the sake of profit maximization within race-to-the-bottom processes of competition, the productive dynamics may lead to increase social fractures and unrest, along with multidimensional vulnerability and risks of exclusion and poverty. If, conversely, the community of entrepreneurs pays consistent attention to the social and environmental context they are embedded in, innovative solutions to align productivity objectives with respect for workers' rights and for the environment may arise, nurturing a path of SHD at the local level. In this regard, according to Becattini (2015), the sense of cohesion, belonging and trust of firms within local production systems may spur processes of productive specialization and complementarity, accelerating evolutionary processes that can contribute to SHD.

2.2.3 Integrated industrial policy approach

Finally, our previous arguments highlight the importance for policy-makers to increase their capacity both to define a vision of industrial development, namely to choose a particular development path, and to implement a set of different but coherent actions that consistently provide the conditions for the movement of the local socio-economic system towards the desired path (Bianchi and Labory, 2019B).

In this regard, the recent academic debate (Berg and Story, 2011; Bianchi and Labory, 2011; Labory and Bianchi, 2018; Martin et al., 2018; OECD, 2018; Pianta et al., 2016; Pike et al., 2017) highlights the need for an integrated policy-making perspective to promote productivity-enhancing, value-added generation and inequality-reducing processes. In particular, if industrial policy is conceived as "systemic" (Aiginger, 2014) and as "a strategy for transition" (Bianchi and Labory, 2019B), then the integration between different – and traditionally separated – policy streams and goals appears more necessary than even before.

An attuned version of the policy mix sundial proposed by Bianchi and Labory (2011) is advanced at this stage, as represented in Figure 3. Building on our arguments discussed so far, the starting point here is that human capabilities and entitlements (i.e. rights to access *de jure* and *de facto*) and provisions (i.e. goods and services) are considered essential elements and levers of industrial development, along with firms' dynamic capabilities (i.e. spurring learning, innovation and resilience processes) and territorial functionings. These levers appear equally important (Bianchi and Labory, 2011) to spur a virtuous circle of SHD at local level, where value-added generation at firm, industrial and place level is pursued along with social improvements and inclusiveness.

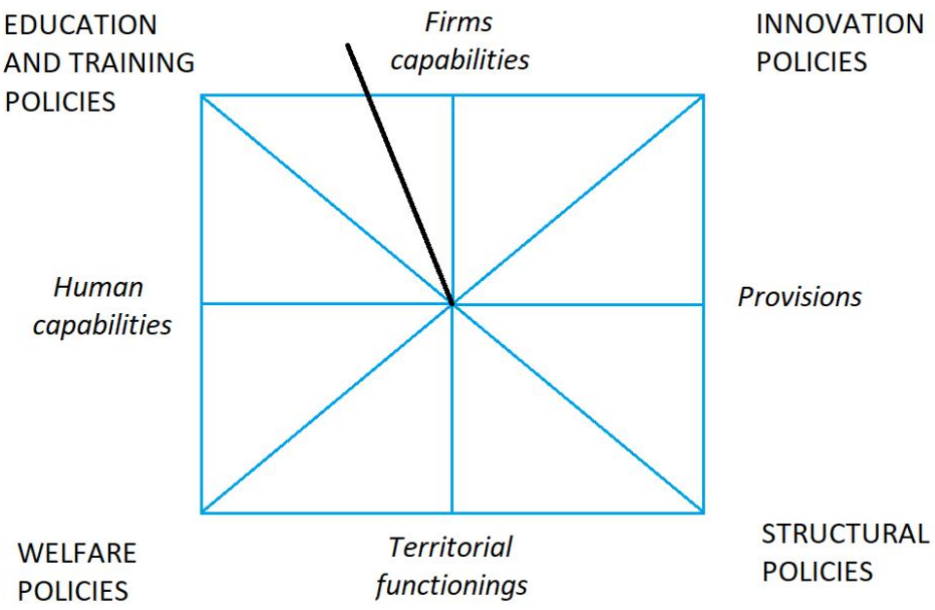
Therefore, the sundial is composed by four axes of policies with different focuses: human capital policies in terms of education and training for basic and advanced skills and competencies, along with diffused learning processes; innovation policies in terms of knowledge creation and diffusion for a transformative change; structural policies

in terms of underlying enabling factors to expand human and productive capabilities (e.g. infrastructural and environmental endowments, institutional architecture); welfare / social policies to ensure basic social needs are met and human rights are guaranteed and exercised.

Unlocking the full potential of an integrated industrial policy approach at local level will involve identifying a distinctive vision of SHD and consistently leveraging positive synergies through coherent policy mixes composed by mutually reinforcing policy actions along with rendering trade-offs structurally non-obstructive.

The sundial shows how its tracker – despite being naturally inclined towards one of these policy axes as primary focus and area of intervention – automatically entails and includes potentially integrated and synergic interventions in all areas and it depicts an effect on all the four levers, which has to be carefully taken into account in all the design and implementation processes. In other words, in the sundial the tracker indicates the starting policy axis, but then the overall strategy must be composed by all axes, each policy intervention must be coherently integrated with each other, paying attention to their inter-linkages, timing and sequencing, and avoiding a silo-based policy approach. This would create several available combinations of policies, prioritising different policy axes and by acting on different levers in different places, or in different times for the same place.

Figure 3. The integrated industrial policy sundial



Source: Authors based on Bianchi and Labory (2011)

All in all, the novelty of our conceptual ground lies is in its capacity to simultaneously combine the three arguments discussed before.

First, any policy would depend on the characteristics of the multi-layered systems in which individuals, social groups, firms and industries are embedded (as in Figure 1). Second, the combination of different elements (e.g. stakeholders and agents, resources, barriers, institutions, capacities, participation spaces and political

willingness) within the individual, collective, place and multilevel dynamics shape the evolutionary processes of, and local patterns for, SHD (as in Figure 2). Third, integrated industrial policy requires devoting fundamental attention to the coherent mix and sequencing of different interventions towards the same strategic objectives (as in Figure 3).

Having in mind these arguments, a place-based political economy framework seems necessary to explore the processes underlying the design and implementation of an integrated industrial policy for SHD at local level.

3. A place-based political economy framework

Our interpretative framework implies that the heterogeneity of the system's actors, the potential diversity of values and divergence of interests and visions within the policy arena at place level open a wide policy space composed by different policy mixes generally available in any place and time. As stressed by Turok et al. (2017, p. 2), 'Much depends on whether democratic institutions are capable of responding to the genuine concerns of citizens and can meld different interests and values together in pursuit of shared agendas and collective solutions.

Therefore, national and regional government intervention – and especially industrial policy – should be analysed not only concerning the effectiveness of specific tools and targets, but primarily concerning the appropriateness of decision-making processes in setting coherent objectives, tools and targets (Di Tommaso and Schweitzer, 2013), consistent with a distinctive shared vision of development. Indeed, institutions and governments can 'enable human flourishing in cities and regions, but they can also facilitate regressive and unproductive forms of development' (Pike et al., 2017, p. 52).

Embracing political economy as a central type of investigation (Cardinale and Scazzieri, 2018) gives us a reading of the social dynamics that cannot be reduced to the sum of individual actions, but which necessarily brings us back to a structural analysis of collective action for human flourishing, especially at local level.

To begin with our political economy enquiry, it is fundamental to stress that industrial policy is not a technical fix, is not neutral and is not designed and implemented in a vacuum. Rather, it is framed 'within an institutionally organized society (polity), with dynamic power relations and political mobilization (politics) shaping collective arrangements for decision-making (policy) transforming the local society' (Biggeri and Ferrannini, 2014, p. 15). In particular, as explained by Cardinale and Scazzieri (2018, p. 3), 'systemic objectives are generated through the mutual weighing (by means of agreement or conflict) of the partial objectives expressed by the principal stakeholders, which may in turn reflect the mutual weighing (also by means of agreement or conflict) of other partial objectives belonging to lower levels of aggregation'.

These arguments lead to keep into account both horizontal and vertical governance relations.

The former emphasises that local development systems are characterized by complex relations among agents and stakeholders within policy networks that, through negotiation, coordination, learning and competition, keep redefining their connections and drive the evolution of the system itself. In this scenario, institutions and policy-making processes are the subject of socio-political contention and represent the arena for the (re)production of social, economic, cultural and political values (Pike et al., 2017). For instance, the sense of community is a form

of social capital that determines the institutional environment in which development takes place (Trigilia, 2001), the capacity to generate consensus and trust, to resolve conflict and to mobilize resources (Rodríguez-Pose and Storper, 2006), the level of provision of public goods (Tabellini, 2010), and the level of economic cooperation and the diffusion of knowledge (Bellandi et al., 2019). We add that collective agency and trust matter, as well as the quality of human relations, the mechanisms for participation and the capacity for critical thinking by local stakeholders (Clark et al., 2019).

The latter highlights 'the existence of overlapping competencies among multiple levels of government and the interaction of political actors across those levels' (Marks et al., 1996, p. 167). A complex and dynamic vertical articulation of responsibilities, competencies and functions among local actors, national institutions and supranational entities requires adapting the instruments of policy actions to the new open and multi-level scenario. Today, the local levels appear to be less and less in a strict hierarchical dependence with the national level and are increasingly moving in the global context with their own autonomy, leading places and productive systems with similar development trajectories, economic specialization and complementarities to meet and strengthen socio-economic relations even when belonging to different countries. In other words, this perspective implies an increasingly direct relationship between regions in a global context, generating dynamic trans-national systems, as evident within the GVCs.

Both understandings of multilevel governance imply that the coordination of policies and actions is not likely to arise naturally, through the actions of an "invisible hand". Rather, as argued by Feldman and Lowe (2018, p. 338), 'the transformation of place is defined by participation in networks, relationships and social experiences, the result of a process that involves political leadership, vision and coordinated action among constituent groups.

Therefore, two policy-making consequences derive from such "rethinking" of the political economy of places.

Firstly, the need for a "whole-of-government" approach that integrates and aligns across sectors, departments and administrative organisations to design and implement integrated, balanced and mutually reinforcing policy packages. In particular, this approach makes operational the integrated industrial policy approach discussed in the previous section and the synergic integration of human capital policies, innovation policies, structural policies and welfare / social policies. The delivery of similar joined-up outcomes towards the intertwined goals of productivity-enhancement, value-added generation and inclusiveness appears extremely relevant, both because any change made by an agent of the system (i.e. a policy body or department in this case) generates structural adjustments in the whole system, as well as 'to get political economy right to avoid piece-meal policymaking leading to both unfilled promises and unintended consequences' (OECD, 2018, p. 131).

Secondly, the coordination and synergic convergence of top-down and bottom-up approaches to local development (Crescenzi and Rodríguez-Pose, 2011). This integration is central in our perspective in order to simultaneously i) fostering participatory policy-making processes based on the interplay of values, interests, ideas, aspirations, discourses and resources from different social groups, stakeholders and agents; ii) avoiding external non-tailored policies imposed from upper levels and detached from place conditions; and iii) eluding isolated local strategies detached from the national and supranational development dynamics.

Nevertheless, we should recognise that the variety of views and interests generates social, economic and subsequently political conflicts within local societies (Biggeri and Ferrannini, 2014). Avoiding a simplistic trivialisation of the social complexity of standard neoclassical model, conflicts due to the heterogeneity of the

system's actors, the diversity of values and the divergence of interests should not be misconceived as automatically detrimental to SHD processes. Indeed, such variety and diversity – if positively expressed within spaces for open, transparent and inclusive policy-making – may act as stimuli to avoid lock-in while setting a collective integrated vision, shaping a strong, compelling narrative of what the challenges and opportunities are and what the desired outcomes should be (OECD, 2018). Subsequently, within socially cohesive societies, it may generate collective actions and joint efforts based on respective competences and responsibilities, accelerating social dynamics towards a shared development trajectory and potentially determining a continuous renewal of the position of the local systems in the national and international arenas.

Last but not the least, in line with our conceptualization of industrial policies, this interplay of multi-layered and potentially conflicting values and interests may spur creative actions and collective learning processes, which are fundamental because structural changes (as the one currently undergoing production systems, business models and work organization) requires timely flexibility, adaptation, adjustments and anticipation (Feldman and Lowe, 2018).

In this sense, according to Becattini (2014), local development systems should act as 'a productive and self-educational structure in continuous evolution' (p. xi), when long-lasting values, knowledge, behaviours and institutions evolve along with functional market changes without producing social fractures or forms of exclusion, leading an increase of economic wealth due to renewed value-added generation to go hand in hand with an increase in human well-being in a given place due to enhanced inclusiveness and cohesion.

Digging deeper in the design and experimentation of integrated industrial policies for a new social cohesion in Emilia-Romagna is just a first attempt to apply our place-based political economy framework and to derive lessons learnt for the international academic and policy debate.

4. Industrial policy for a new social cohesion in Emilia-Romagna

4.1 The relevance of the case-study

The recent experience of the industrial policies in the Emilia-Romagna (E-R) region can be considered an interesting and appropriate case-study to be analysed from a place-based political economy framework, building on the long lasting empirical analysis on E-R in the international literature on industrial districts and clusters (see Brusco, 1982, as starting point).

E-R represents a region where a new vision, perspective and decision-making method on industrial policy has been experimented since 2012, being a potentially valuable policy lab for other regions in Italy and around the world facing similar challenges and conditions.

This case represents a powerful test of design and implementation of a place-based policy driven by a new attitude that combines in synergic manner economic and industrial dynamics with the improvement of people's well-being, participation and social cohesion to tackle relevant issues and challenges within the regional society at large. This shift on industrial policy was prompted by policymakers since good economic performances in E-R had failed to fully translate into social progress. As a matter of fact, the Social Progress Index computed by the European Commission on data for the period 2008-2013 reported a level for E-R equal to 60.78, ranking 191st

out of total 272 European regions and under-performing compared with the 15 European regions with similar GDP per capita (EC, 2016).

Therefore, complementing the analysis proposed by Bianchi and Labory (2019A) on how the four main enabling conditions of regional industrial policy – i.e. capabilities, networking, governance and policy coherence – have been made operational in E-R, we re-analyse how its industrial policies have been designed, implemented and adjusted in light of our people-centred and place-based perspective and our place-based political economy framework. Our analysis in based on systematic policy review of official documents and semi-structured interviews with key informants within public, private and civil society sectors.

4.2 Main features and recent performances of Emilia-Romagna

Emilia-Romagna is an Italian region with almost 4.5 million inhabitants in 2020 (7.4% of total Italian population with a 2.9% increase between 2012 and 2020) and almost 158 billion euro of GDP (around 9% of Italian GDP). It hosts a long-lasting industrialised area based on small- and medium sized firms (more than 350000 firms with an average size of 3.9 employees) characterised by flexible specialisation and competition. Its renowned quality and value-added lies especially in advanced sectors such as agro-food, engineering, machinery, packaging, automotive, ship building, ceramics, pharmaceutical, chemical, and biomedical instruments, as well as in traditional sectors like textile, clothing, shoes, furniture, and constructions (Andreoni, 2018).

The financial and economic crisis that has been deeply affecting the Italian economy since 2008, coupled with the 2012 earthquake that hit the industrial core of the region, forced E-R to engage in a process of structural change centred on the renewal and expansion of systemic capabilities and on the transformation of production processes toward value-added generation and high-value production phases within GVCs.

Recent economic indicators for Emilia-Romagna and Italy are reported in Table 1, showing the capacity of the regional economic system to generate and sustain value-added, employment opportunities and income, with positive trends in the recent past in almost all variables. It is particularly interesting to note the levels of GDP per capita, GVA per worker and employment (respectively as proxies for wealth, labour productivity and job inclusion), which are substantially higher than the national value. Moreover, the role and performance of exports are illustrative of the international openness and capacity of the region to take and keep a lead within GVC, implying both wider economic opportunities but also higher potential vulnerabilities linked to external factors. All in all, the fate of the region appears less tied economically to the state of the Italian economy than it once was, although also benefiting from a stronger complementarity with other regions and actors within a wider national perspective.

Table 1. Recent economic indicators for Emilia-Romagna and Italy

Indicator	*Emilia-Romagna*	*Italy*	*Source*
GDP per capita - 2018 (thousands €) and 2013-2018 variation	36.3 (+11.7%)	29.2 (+9.4%)	ISTAT
Regional Gross Value Added - 2018 (millions €) and 2013-2018 variation	141339 (+7.5%)	1544980 (+5.3%)	OECD Stat
Regional Gross Value Added per worker - 2018 (millions €) and 2013-2018 variation	65040 (+2.7%)	60925 (+1%)	OECD Stat
GVA in manufacturing - 2017 (% of total GVA) and 2013-2017 variation	24.8 (+14.1%)	16.6 (+10.6%)	OECD Stat
GVA in industry, including energy - 2017 (% of total GVA) and 2013-2017 variation	27.1 (+13.3%)	19.5 (+8.2%)	OECD Stat
Employment rate - 2019 (%) and 2015-2019 variation	70.4 (+5.5%)	59.0 (+4.8%)	Eurostat
Employment rate MALES - 2019 (%) and 2015-2019 variation	76.7 (+3.9%)	68.0 (+3.7%)	Eurostat
Employment rate FEMALE - 2019 (%) and 2015-2019 variation	64.1 (+7.4%)	50.1 (+6.1%)	Eurostat
Employment in manufacturing - 2017 (% of total employment) and 2013-2017 variation	21.4 (-0.4%)	15.5 (-1.3%)	OECD Stat
Employment in industry, including energy - 2017 (% of total employment) and 2013-2017 variation	22.4 (-0.1%)	16.8 (-0.8%)	OECD Stat
Exports – 2019 (millions €) and 2013-2019 variation	66.344 (+30.6%)	475.848 (+19.2%)	ISTAT
Exports as % of GDP - 2019	41.0	31.6	Union Camere / World Bank

Source: Authors based on different sources

Relevant social and environmental indicators are reported in Table 2, showing a positive performance of the region – as compared to Italy – on the reduction of inequality, social exclusion and gender disparity in the past years, but highlight also significant weaknesses on CO2 emissions and electricity from renewable sources, with negative recent performances also as compared to Italian improvements.

Table 2. Recent social and environmental indicators for Emilia-Romagna and Italy

Indicator	*Emilia-Romagna*	*Italy*	*Source*
Gini index for disposable income (after taxes and transfers) (0-1) - 2013	0.302	0.325	OECD Stat
Gini index (before taxes and transfers) (0-1) - 2013	0.476	0.514	OECD Stat
Disposable income inequality - 2017	4.5	6.1	BES ISTAT
Sub-national Human Development Index - 2018 (0-1) and 1990-2018 variation	0.91 (+12.3%)	0.88 (+14.3%)	Global Data Lab
People at risk of poverty or social exclusion - 2018 (%) and 2015-2018 variation	14.2 (-7.8%)	27.3 (-4.9%)	Eurostat
Young people (15-24 years) neither in employment nor in education and training (NEET) - 2019 (%) and 2015-2019 variation	12.1 (-23.9%)	18.1 (-15.4%)	Eurostat
Severe material deprivation rate - 2018 (%) and 2015-2018 variation	2.9 (-50.9%)	8.5 (-26.1%)	Eurostat
Unemployment rate - 2019 (%) and 2015-2019 variation	6.1 (-21.8%)	10.0 (-16%)	Eurostat
Unemployment rate MALES - 2019 (%) and 2015-2019 variation	4.7 (-28.8%)	9.1 (-20.2%)	Eurostat
Unemployment rate FEMALES - 2019 (%) and 2015-2019 variation	6.6 (-27.5%)	11.1 (-12.6%)	Eurostat
Youth unemployment rate (population aged 15 to 24 years - 2019 (%) and 2015-2019 variation	18.5 (-37.3%)	29.2 (-27.5%)	OECD Stat
Average hourly earnings for employee jobs in the private sector MALES - 2017 (€) and 2014-2017 variation	15.4 (+1-2%)	11.6 (+1%)	ERVET / ISTAT
Average hourly earnings for employee jobs in the private sector FEMALES - 2017 (€) and 2014-2017 variation	13.1 (+2.2%)	10.8 (+2.4%)	ERVET / ISTAT
Participation rate in education and training (last 4 weeks) (population aged 25 to 64 years) - 2019 (%) and 2015-2019 variation	10.4 (+19.5%)	8.1 (+11%)	Eurostat
CO2 emissions per capita - 2018 (kt) and 2015-2018 variation	7.6 (+7%)	7.3 (-1.4%)	ART-ER / Eurostat
Electricity from renewable sources - 2018 and 2015-2018 variation	19.7 (-1.5%)	34.3 (+3.6%)	BES ISTAT

Source: Authors based on different sources

These data are also confirmed by the ISTAT regional accounts on Equitable and Sustainable Well-being (BES), whose last report released in 2019 highlight a very positive performance by E-R especially in the dimensions of education and training, employment, income and inequality.

Latest data by OECD on Sustainable Development Goals (UN, 2015) reported in Table 3 again confirm this interpretation. They highlight E-R performs better than the Italian average in 12 SDGs (mostly concerning social and economic sustainability) and better than the OECD average in 8 SDGs, including SDG#9 on "Industry, innovation and infrastructure" among others. However, it under-performs as compare to both the Italian and

OECD average on certain environmental Goals, in particular on responsible production and consumption (SDG#12) and on terrestrial and marine eco-systems protection (SDG#14 and #15).

Table 3. Overview of Emilia-Romagna performance in each Sustainable Development Goal

Sustainable Development Goal (SDG)	*Emilia-Romagna*	*Italy average*	*OECD average*
SDG#1 No poverty	99	69	68
SDG#2 Zero hunger	98	71	62
SDG#3 Health and well-being	94	93	68
SDG#4 Quality education	59	49	59
SDG#5 Gender equality	57	50	60
SDG#6 Clean water and sanitation	81	76	69
SDG#7 Affordable and clean energy	88	47	64
SDG#8 Decent work and economic growth	70	43	76
SDG#9 Industry, innovation and infrastructure	52	33	49
SDG#10 Reduced inequalities	91	82	77
SDG#11 Sustainable cities and communities	62	66	73
SDG#12 Responsible production and consumption	15	38	70
SDG#13 Climate action	47	36	68
SDG#14 Life below water	37	52	42
SDG#15 Life on land	44	58	58
SDG#16 Peace, justice and strong institutions	69	66	72
SDG#17 Partnerships for the goals	55	59	64
Note: End value for 2030 equal to 100 in each SDG.			

Source: Authors based on OECD Measuring the distance to the SDGs in regions and cities https://www.oecd-local-sdgs.org/index.html (last accessed on 23rd July 2020)

4.3 Recent industrial policy for a new social cohesion

Taking into account the strengths and weaknesses of the regional socio-economic system after years of strong recession in Italy and after the 2012 local earthquake, a new policy-driven process of regional transformation and renewal was prompted by the collective pursuit of a shared local vision and narrative linking productivity and value-added generation with inclusiveness and cohesion.

The starting point was the definition of a new integrated industrial policy in the "Labour Pact: A new development for a new social cohesion", officially adopted in July 2015, followed by the "Labour Pact – Youth plus: More spaces, more competences, more services, more entrepreneurship, more rights and autonomy, more jobs". These Labour Pacts arose precisely to respond to the need to re-construct a long-run vision and consensus able to sustain the structural change of the economy and the society. In particular, the Labour Pacts combine the support to innovation, value-generation and upgrading with knowledge diffusion, skills enhancement and high-level training, and they integrate the synergic objectives of increasing productivity with expanding economic opportunities for all (and especially for the youth).

Within our place-based political economy framework, the most relevant feature of the Labour Pacts was probably the policy-making process in itself, which involved the most important regional stakeholders in the public, private, social and research sectors in the definition of the regional priorities and goals. The Labour Pacts

were discussed, shared and signed by around 50 stakeholders – i.e. business associations, trade unions, universities, municipalities and provinces, NGOs, civic associations – within a democratic and participatory concertation process where the variety of views, interests and ideas was seen as generating value towards SHD and social transformation.

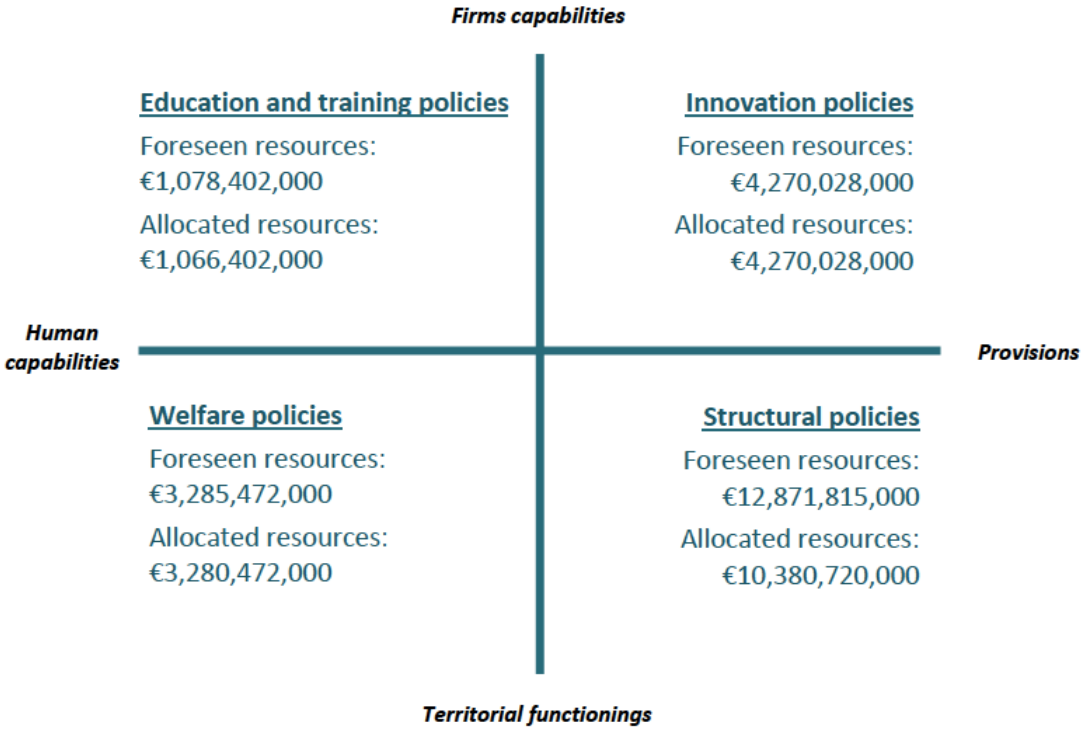
Key actors and stakeholders at regional level participated since the beginning in the entire participatory process, guaranteeing a continuous presence at the meetings in which proposals for action were shared and the results of the collective action were verified. Nevertheless, during our fieldwork, it was reported that divergences and contrasts emerged in the collective discussion of the Labour Pacts. However, they were more prominent not among different social groups and stakeholders (as one would have expected), but rather within certain organizations, and especially between those representatives more prone to embrace a long-term vision and integrated policy approach and those more concerned with immediate internal interests. Such divergences were manifested, discussed and resolved through a social dialogue that put at centre stage the coherence to the societal interest, and the shared responsibility and consistency towards an overarching SHD vision and strategic objective of value-added enhancement in the regional economy (Bianchi et al., 2020). Moreover, this process allowed the convergence between sectoral and territorial interests and priorities, both within each policy axis and towards the common overarching vision.

All in all, rather than a negotiation, this policy approach led to the collective commitment in the form of "Pacts", allowing the collective reflection and creation of a new long run vision of development, in order to let all public, private and social actors play together to make policy choices viable by aligning and committing efforts, strategies and resources towards shared goals.

Such processes have implications not only in terms of policy design, but also on its implementation, by pushing towards a whole-of-government approach in terms of a new structure and functioning of regional administrative organization and management consistent with the societal vision and objectives of the Labour Pacts. In particular, there was a shift from 10 to 5 Directorates-General, with responsibilities linked to inter-wined policy fields, along with a Directorate-General in charge of coordination of all European policies and funds for development (Bianchi et al., 2020). As pointed out in our field work, making such whole-of-government approach operational has obviously been challenging, especially due to resistances and rigidities within the regional administrative apparatus in i) adopting a long-term vision spanning well beyond legislature times, and ii) changing its structure to operate in a more integrated, transversal and discretional way to be consistent with the new policy approach. For these reasons, such re-structuring of the regional administrative organization is still underway and needs a continuous enhancement to become structurally consolidated.

In terms of budgeting, the policy resourcing support was based on the capacity to convey all different budget sources towards the Labour Pacts (increasing from 15 to 22 billions euro between 2015-2019) and to attract additional funds available at national and European level towards the same overarching vision. The foreseen budget resources devoted by the regional government for the Labour Pacts can be divided in the four policy axes of the sundial, as represented in Figure 4.

Figure 4. Budget resources devoted to the Labour Pacts (2015-2019)



Source: Authors based on administrative data

4.4 Multi-level relations

This integrated industrial policy approach has been affecting also the relations with the central government of Italy.

On the one side, it has been exacerbating existing divergences between national and regional policy-making levels. Indeed, central government institutions and departments, as well as national representatives of the same stakeholders (e.g. entrepreneurial associations, trade unions) involved in the Labour Pacts at local level in E-R, conceive economic policy to be a national responsibility, with regional actors in charge of the implementation of centrally defined strategies. In other words, an institutional and political opposition was reported in terms of vertical multi-level relations, limiting the capacity and role of regional actors in advancing industrial policies with a national value, due to territorial cohesion concerns by the centre.

On the other side, it has been widening the opportunities for multi-level dialogue and enhancing the proactive capacity of the regional government to advance strategic proposals able to reconcile regional and national interests, by reinforcing territorial partnerships and complementarity among Italian regions enabling an indispensable acceleration to get the whole country out of the stagnant condition of the national economy. This appears especially relevant within the chaotic sense of industrial policy in Italy (Simonazzi, 2015), showing how the design of an integrated industrial policy – based on collective design of a place-based SHD vision and going beyond the simplistic discussion about horizontal and vertical incentives and subsidies (strictly focused on tools and targets without discussing societal goals) – may represent a feasible and common path for regional economies and societies.

Similarly, at international level E-R has proactively developed a vast network of territorial partnerships, in particular through formal agreements with Hessen (DE), Aquitaine (FR), Wielkopolska (PO), Guangdong (CN) and California (US), among others, and active involvement in several networks of regions promoted by the European international and territorial cooperation policy (e.g. the case of Adrion Programme).

Therefore, this integrated regional industrial policy does not represent a mere local policy, but rather it has been truly designed as a people-centred and place-based with a national and international projection.

4.5 Strategic policies and initiatives

In concrete terms, if we apply the sundial (see Figure 3 above) to the industrial policy for a new social cohesion in E-R, we easily find the policy tracker to be inclined towards the upper part: primarily, towards education and training policies to expand basic and advanced knowledge and skills, and secondly, towards innovation policies to expand firms' dynamic capabilities, thus leveraging upon the strict and undeniable relationship between education, training and production organization.

On education and training policies, the first action was to reform and re-organize the entire education and VET structure towards an integrated system able to connect different knowledge caches, skills and capabilities to the entrepreneurial and production system. By combining in a holistic vision the acquisition of basic knowledge, critical thinking attitudes and transversal skills in primary and secondary education with advanced skills and competencies, on-going learning and professional development in tertiary education and vocational training, the reform aimed at supporting the structural transformation of the economy and the society, accelerating its dynamics and ensuring its adaptation to changing conditions. The premise here was that education and training policies are pivotal to coherently link with all other policy axes due to their simultaneous focus on people, enterprises and societal issues and their long-run frame. In other words, this policy action concerns setting an enabling environment that allows research and high education to become production capabilities, capable of generating a high value-added for the community, repositioning the territory on a global scenario and responding more and more both to individual needs and the great global challenges.

For instance, new advanced technical schools were set as independent foundations among companies, public schools, universities and local institutions to provide future managers and workers with high technical and managerial skills and a learning attitude towards continuous knowledge acquisition, research and innovation. In a similar multi-stakeholder vein and as part of the regional Smart Specialization Strategy, the regional government promoted the establishment of the Motorvehicle University of Emilia-Romagna (MUNER). It represents an experimental attempt to combine the know-how and the most innovative technologies of some of the most famous automotive Companies in the world (i.e. Automobili Lamborghini, Dallara, Ducati, Ferrari, HaasF1Team, HPE COXA, Magneti Marelli, Maserati, Pagani, Scuderia Toro Rosso) with the research and education capacities of the main universities in E-R, in order to design and provide six new automotive engineering careers of the future. Despite having long been a priority area of policy intervention by the regional government, MUNER is illustrative of the new approach on making the relationships among government-industry-university systematic, strategic and forward-looking towards value-added enhancement within the GVC.

Moreover, an additional reform in the area of education, training and jobs was the creation of the Regional Employment Agency based on the interaction of the three levels of employment promotion – i.e. public employment centres, private employment agencies and an employment active alliance (composed by training centres, entrepreneurial associations, trade unions organizations) – in an integrated network and involves the whole society to create new employment.

Finally, this education and training strategy focused on value-added generation and strong linkages with the production sector directly deals with social sustainability concerns, with particular attention to the youth (e.g. through the Labour Pact – Youth plus) and local communities as clear in the policy response after the 2012 earthquake.

On innovation policies, E-R has developed a broad R&I strategy and a strong regional innovation system based on its technical expertise in advanced and traditional sectors and on the academic expertise of universities and national research institutes operating in its territory.

Table 4 displays relevant R&I indicators for Emilia-Romagna, clearly showing a much stronger regional innovation system as compared to the country, especially in terms of R&D human resources and expenditure.

Table 4. Recent R&I indicators for Emilia-Romagna and Italy

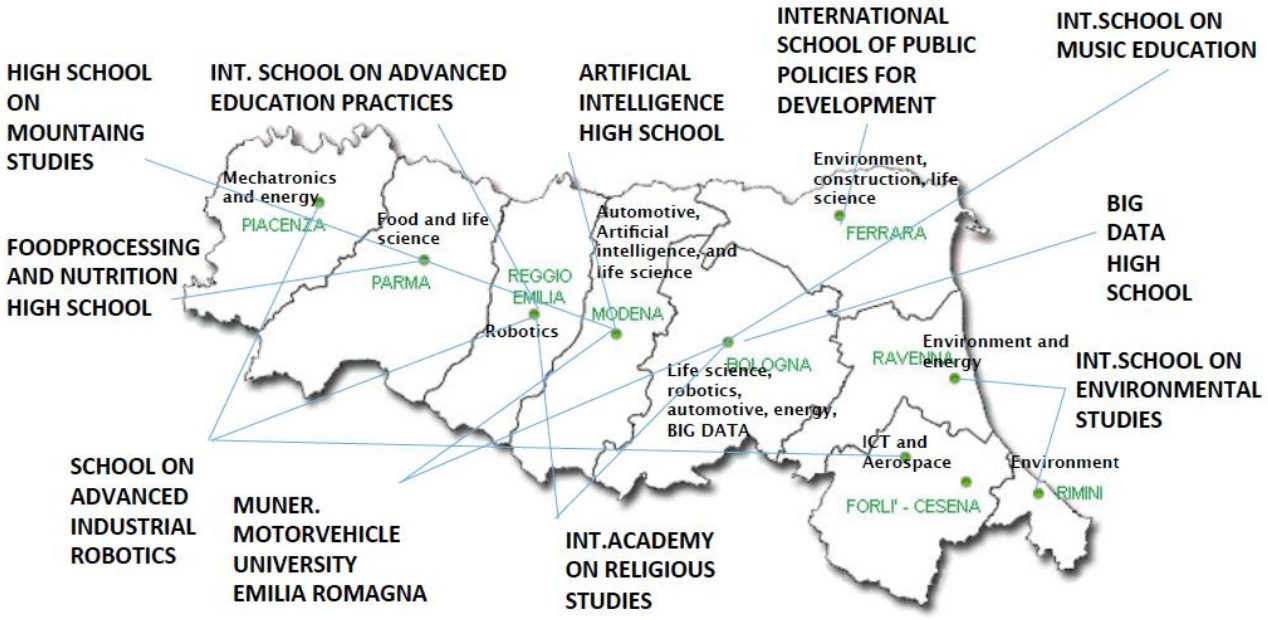
Indicator	*Emilia-Romagna*	*Italy*	*Source*
Total R&D personnel and researchers (Full-time equivalent) - 2017 (thousands) and 2013-2017 variation	42.158 (+42.7%)	317.628 (+28.7%)	Eurostat
Total R&D personnel and researchers (Full-time equivalent) - 2017 (% of active population) and 2013-2017 variation	1.99 (+40.5%)	1.25 (+26.1%)	Eurostat
Total R&D personnel and researchers (Full-time equivalent) - 2017 (number per 10,000 inhabitants)	37.1	23.2	Istat
Intramural R&D expenditure - 2017 (€ per inhabitant) and 2013-2017 variation	701.4 (+30.3%)	392.7 (+11.7%)	Eurostat
Employment in technology and knowledge-intensive sectors - 2019 (thousands) and 2013-2019 variation	2021.2 (+5.9%)	23280 (+4%)	Eurostat
Firms with process and/or product innovative activities - 2014/2016 (%)	46.0	38.1	Istat

Source: Authors based on different sources

As explained by Bianchi and Labory (2019A), the Research and Innovation Strategy for Smart Specialization (RIS3) in E-R was designed with the same spirit (e.g. consistency to the societal vision, coherency with and among policy fields, conscious and participatory governance, integration with European and national policies) to implement coordinated policies towards clear strategic innovation and competitiveness objectives. Counting on a total of 2.5 billion euro (including European funds, regional and national resources and private co-financing), the RIS3 in E-R integrates the existing innovation eco-system with broader development policies, and it promotes an acceleration in the processes of transformation and renewal of the regional economy. Moreover, it frames regional specialization within a national and European logic of "smart complementarity", in order to make specialization in E-R not only a distinctive feature for the benefit of the regional system but also a value-added for the whole country spurring synergies and linkages with other regions.

In line with the regional RIS3, the industrial policy envisaged within the Labour Pacts has promoted a network of techno-poles according to the relative advantages and industrial expertise of each place (Figure 5).

Figure 5. The network of techno-poles and high schools in Emilia Romagna



Source: Bianchi et al. (2020)

Each techno-pole thus constitutes the hub of the regional network in the specific research cluster – Health and Well-being, Agri-food, Culture and Creativity, Mechanics and Motorvehicles, Energy and Environment, Building and Construction, Innovation and Services – where around 263 organizations participate as members to share ideas, skills, tools, resources supporting the competitiveness of the E-R production systems.

Within this interdependent network, a central relevance is today assigned to the Emilia-Romagna Big Data community and the Big Data Techno-pole in Bologna. This initiative started from the recognition that E-R is a national and European hub for big data, as about the 70% of the Italian research data is stored/processed in regional research centres. For these reasons, a Big data techno-pole on research and applications on global goals has been set-up in Bologna to foster fundamental analytics and applications for science, industrial and societal challenges, such as: Climate change; Health and aging; Production and innovation; Humanities and society; Sustainable cities; Security and Cybersecurity; Education. Last by not the least, the E-R regional government is setting-up, together with the Emilia-Romagna Big Data community, the "Foundation on Big Data and Artificial Intelligence for Human Development" to try out new ideas and push boundaries in research, education, and entrepreneurship for a new sustainable development.

Here again, we can briefly highlight how this research and innovation strategy based on specialized techno-poles and strong government-industry-university collaborations directly deals with environmental and social sustainability questions, in the sense of pooling competences and resources and assigning priorities to several societal challenges (e.g. on climate change, green industries, renewable energy, health, smart cities) of our times. This represents another important novelty of this integrated industrial policy made possible by the design and collective commitment of a SHD vision for the regional economy and society.

Taken together, the main difference between before and after this new policy approach in E-R – both for education and training as well as for research and innovation policies – lies in designing them to proactively

pursue a regional transformation and renewal towards SHD, through a structured and organized planning systems for each intervention.

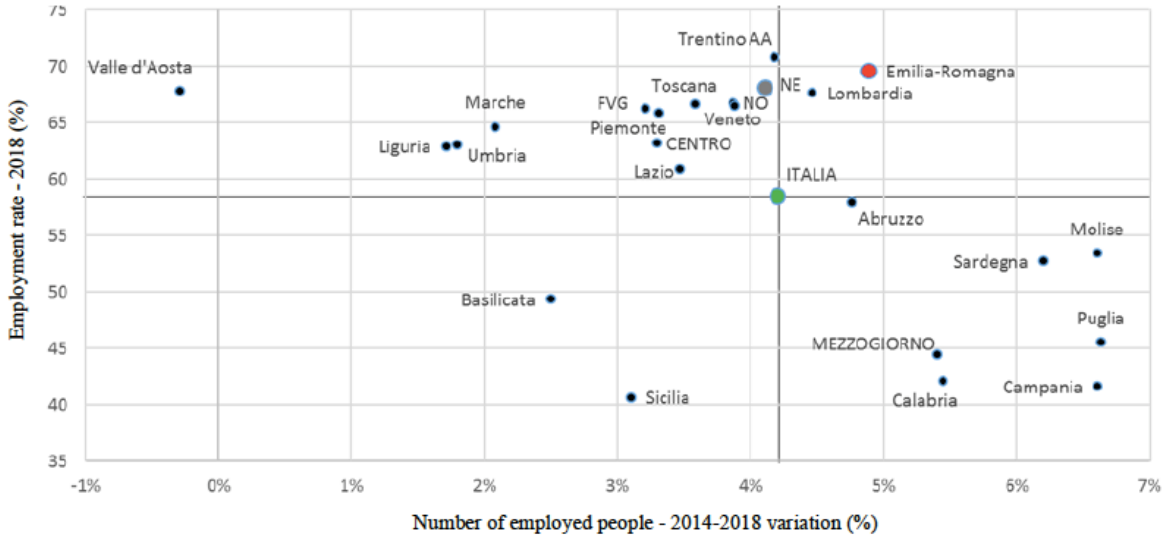
4.6 Preliminary assessment

So far, it is possible to highlight that recent regional and comparative data are reporting positive preliminary results in terms of variations since 2013-14 to 2018-19, although a time span of five years is clearly a short period for a robust assessment and evaluation of these policies. Moreover, it is clear these policies will fully reveal their economic and social effects only in the long run.

On value-added generation, the regional gross value-added has grown by 7.5% between 2013 and 2018 (constant prices) with a yearly positive increase since 2014, reaching up to more than €141 billions. This points that the overall labour productivity is recovering from the previous disruptions derived from the recession and 2012 earthquake. Moreover, it seems the new industrial policy is affecting also value-added composition, with a marked increase in manufacturing and industry.

On labour market inclusion, E-R clearly over performs both in terms of employment level and growth rate as compared to other Italian regions (Figure 6). For instance, employment rate has been increasing by 5.5% in the past 5 years (especially for females) and unemployment rate decreasing by -21.8%, with a particularly strong improvement on youth unemployment (-37.3%).

Figure 6. Employment rate (2018) and recent variation (2014-2018) in Italian regions.



Source: Authors based on data provided by ART-ER

On investments, the Labour Pacts seem to have stabilized expectations and paved the way for a drastic growth of gross fixed investments, i.e. + 18% over 2014-2018 as compared to – 32.5% between 2008 and 2014. This is also paying back in terms of attraction – and permanence – of firms especially in high-value production phases within GVCs, with an increase in the stock of inward FDI by 43.5% over 2014-2017 that confirms the high attractiveness of the region for European and global investors. The outstanding increase in exports (+30.6% between 2013-2019) is another confirmation of the positioning of the regional system within GVCs.

On education and training, promising results were recorded with an increase in upper secondary education rate up to 97.6% and tertiary education rate up to 34.4% (+9.3% between 2014-2018), and the relevant reduction in school dropout to 11% (-2.2% between 2014-2018).

This also reflects in terms of social inclusion, with marked improvements concerning NEET (-23.9% between 2015-2019), risk of poverty and social exclusion (-7.8% between 2015-2018) and several material deprivation to less than 3% in 2018.

The features and preliminary results of the regional integrated industrial policy appear today promising (though too early to be evaluated) also to enable the resilience of the regional system against the social and economic consequences of the Covid19 pandemic. As already in the aftermath of the earthquake in 2012, such a place-based and participatory approach to integrated industrial policy may more easily lead to a collective response and recovery based on shared responsibilities towards the common good and facilitated by structured coordination mechanisms towards a vision of SHD. For instance, a yearly collective appraisal of the Labour Pacts allows to calibrate it to new conditions and priorities (within the same overarching vision). This has been paving the way for the collective design of a new Pact 2021-2027 on "Labour and Climate" (officially approved and signed by 56 regional and local stakeholders in December 2020) to tackle the societal challenges on environmental sustainability – on which regional performances have displayed relevant weaknesses so far – as the new driver for the structural transformation of the regional economy and society.

5. Final remarks

In this paper we argue that reconciling the objectives of value-added generation and productivity-enhancement with inclusiveness and social cohesion requires both the enhancement of a new vision underlying integrated industrial policy and the structural analysis of policy and collective action in places.

Starting from the recognition that the diversity of interests, needs and ideas make local systems change, our place-based political economy framework conceives each local development system as a social construction built on interactions among individuals and organizations embedded in multi-layered systems (Figure 1), which generate and manage conflicts, share knowledge and learn, take and implement individual, collective and local initiatives and thus shape the overall evolution of the system itself (Figure 2). An integrated industrial policy for SHD at place level can thus be designed only when the inter-linkages between these dynamics and the variety and diversity of views, interests and ideas act as stimuli to avoid strict path dependence and lock-in, while setting a new shared vision for the structural change of the local economy and society. This must be pursued by overcoming traditional silos-based and sectorial policy, towards decision-making and operational arrangements based on a 'whole-of-government' approach, where synergies and coherence among policy areas are consistently leveraged towards a unifying vision (Figure 3).

In a similar political economy framework, the collective design and discussion of policies entails a real process of institutional change, which involves reshaping political incentives to favour participatory governance and whole-of-government mechanisms and gradually removing the most binding institutional constraints to economic development and social progress.

The case-study of the Emilia-Romagna region is thus illustrative of how transformative changes towards Sustainable Human Development can be made operational at regional level through an integrated industrial policy approach. Far from being a best practice as evidence of results and their attribution to implemented policies requires a longer time spam and different methodologies, it can be considered as a policy lab from which it is possible to derive some potential lessons learnt on the main principles for integrated industrial policy potentially adaptable to different settings and places.

Firstly, the "participatory and conscious governance" principle, by promoting an open and inclusive institutional environment for participation by local stakeholders to question the status quo and collectively define a societal development vision.

Secondly, the "consistency" principle, by fostering shared commitment and responsibility and facilitating long-term partnerships to collectively pursue the societal vision through multi-level alignment and policy coherence.

Thirdly, the "integration" principle, by grounding the transformation, renewal and resilience of places on synergies among policy axes and mutually reinforcing policy actions.

Fourthly, the "organizational" principle, by effectively adapting the structure and functioning of the regional administrative organization and management to a whole-of-government approach consistent with the societal vision and objectives.

Fifthly, the "transformation" principle, by shaping the economic and industrial dynamics to sustain a structural transformation of the regional system in the long run, as in a classical political economy perspective (Cardinale and Scazzieri, 2020).

Anyway, these remarks do not – and cannot in any way – lead to a universal fix and policy recipe on integrated industrial policy for SHD in places. Rather, they are potentially adaptable to other places facing similar challenges, as the same vision – or strategic objective – can be pursued by prioritising and sequencing different policy axes and by acting on different levers in different places, or in different times for the same place, according to contextual and conjunctural conditions and political willingness.

Going beyond these preliminary insights from the E-R experience, future research will thus potentially move in at least three directions. Firstly, it is required to further theoretical advancements to sustain integrated industrial policy for SHD, placing the economic dynamics at the centre of processes of structural transformation of our societies at local level. Secondly, it is necessary to derive more systematic evidence from a wider array of case-studies around the world and from comparative analysis on the design and implementation of policies addressing the productivity-inclusiveness nexus. Thirdly, it is important to dig deeper into a place-based political economy investigation on real-world policies, in order to understand how different values, interests and powers within local societies allow or prevent the shared setting and collective pursuit of a vision of SHD.

These research lines will potentially pave the way for the diffusion of a new policy agenda dealing with the twin challenges of combatting inequalities and increasing value-added at place level. In a post-Covid19 scenario, such policy agenda would support the formulation of public policies with the aim to consolidate the social value of institutions and, at the same time, it would support the generation of high value-added for the local community, tackling collective needs and exclusionary processes and contributing to promote Sustainable Human Development.

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FINAL REMARKS

The underlying argument of all these papers is that a turning point on the connection between industrial policy and sustainable human development has been reached, whose urgency is apparent in the Covid19 era.

On the one side, despite industrial policy has long been a contentious issue in academic and policy debates, today we are witnessing a rethinking of its role, being industrial policy increasingly conceived through a systemic approach that deals with all elements of production dynamics, extends far beyond the correction of market failures and pursues societal goals for the sake of long-run collective interest. Moreover, the current technological upgrading of industrial production and the new ways of its organization are bringing about new types of players and new types of interaction characterizing the value-creation processes and are going to transform workplaces and living environments. This is ultimately leading to a new production paradigm and reshaping socio-economic life more broadly.

On the other side, an integrated notion of sustainable human development – i.e. combining environmental concerns and awareness on planetary limits to growth with both people's inclusiveness, equality of opportunities and wellbeing, and with shared and long-term societal prosperity – has been gaining momentum in both the academic and policymaking spheres. The balance among the three dimensions of sustainability – the economic, social and environmental – is one of the hall-marks of the UN Agenda 2030 for Sustainable Development, whose goals and targets are integrated and indivisible, global in nature and universally applicable. The notions of 'indivisibility' and 'integration' lead to pay stronger attention to improved multi-level governance and policy implementation, as well as to multi-actor responsibility in the pursuit of sustainable human development, linking global, regional, national and local levels, as well as public, private and social actors, and cutting across policy fields. Moreover, they have been calling for a qualitatively different way of thinking about economic (and industrial) policy, extending it to reconcile the objectives of value-added generation and productivity-enhancement with inclusiveness, social cohesion and environmental protection.

Within this scenario, the Covid19 pandemic is somehow accelerating the shift in the academic and policy-making spheres on industrial policy, revamping attention on the need for public action and government intervention on production dynamics both to tackle dramatic economic and social problems in the short run and to steer the structural transformation of the economy and the society in the medium and long run.

Nevertheless, sustainable human development does not seem to have been placed at the very centre of industrial policy yet, calling to devote dedicated attention to their nexus by the academic debate, as preliminary attempted in these papers.

In the first paper ("*Industrial policy for sustainable human development in the post-Covid19 era*"), it was argued that it is today necessary to fully reflect an integrated notion of sustainable human development both in the academic debate and in the real-world practices of industrial policy. Such shift urges us to rethinking both the theoretical foundations, as well as governance and implementation processes of industrial policy.

This implies primarily that industrial policy must be fundamentally tied to a value-based societal vision able to reconcile sustainability and development, and that the technical, functionalist and normative perspectives on industrial policy should be linked one another avoiding a detrimental separation and misalignment between

them in policymaking processes. Consequently, industrial policy governance and implementation must be at the centre of a policy framework shaped both by a normative societal vision and a new understanding of the multiple inter-linkages and feedbacks among industrial policy economics, political economy, and management, as well as by shocks and changes emerged within and outside each economic and social system.

These arguments have led to identify a set of preliminary implications about key policy issues – i.e. co-determination of societal vision and objectives; institutional arrangements for civic engagement and voicing capacity; policy coherence and multi-level alignment; government capacity and complexity; monitoring and evaluation – that together remark the need to invest in the accurate and transparent design of industrial policy in the post-Covid19 era. They imply to establish skills, resources, capabilities and structures in public organizations to be effective at planning and learning in partnerships with the private sector and civil society, as well as at deploying and strategically coordinating multiple policy instruments and institutions addressing complex interdependencies.

In the second paper ("*Tracking the SDGs in an 'integrated' manner: A proposal for a new index to capture synergies and trade-offs between and within goals*"), it was argued that the pursuit of each Sustainable Development Goal (SDG) as in the Agenda 2030 is a necessary but not a sufficient condition for the achievement of a balanced and integrated form of sustainable development. Although SDGs and their targets are not independent of each other, they are indivisible in the sense that they make unique contributions to overall development. In other words, the pursuit of a balanced and integrated set of SDGs is a necessary condition for the success of Agenda 2030. It follows that there is a pressing need to analyse and monitor overall progress towards sustainable development across countries through an effective aggregate indicator that can complement dashboard and scorecard approaches and play, despite well-known limitations, a clear advocacy role, ensuring transparency and accountability at all level of governance, and shaping new strategic policy actions for sustainable development. For these reasons, building on the SDG Index introduced by Bertelsmann Stiftung and Sustainable Development Solutions Network, a new Integrated Sustainable Development Index (I-SDI) was introduced to better capture the integrated nature of the SDGs by incorporating synergies and trade-offs between goals and targets. The I-SDI – inspired by the Multidimensional Synthesis of Indicators approach – has political value insofar as it encourages countries to appreciate the importance of pursuing synergies between goals, targets and indicators within an overarching sustainable development strategy. Although a certain degree of arbitrariness may well be inescapable, a deeper empirical understanding of the linkages and interactions between goals and indicators, and a more flexible approach to monitoring them can significantly increase awareness and consciousness of the selection of parameters as well as subsequent policy choices.

In the third paper ("*Industrial Policy and Societal Goals: A New Look at the American Case*"), it was argued that it is evident that the US Federal government have been adopting belief systems and values that shape and define its policies, thereby influencing the transformation of the US economy and society. In this regard, it was shown that it is necessary going beyond the ideological polarization in the industrial policy debate that opposes unconditional confidence in the market and individual economic freedom to the idea that industrial development *must* rely on government guidance. Despite emphasis on the strength of free markets, government policy has

been interventionist (since Hamilton to Trump) through the various stages of the US industrialization, deploying actions motivated either by short-term economic, social, and political necessity, or by the willingness to achieve more complex structural adjustment and national societal goals. The discussion of the real-world policy practices of the US government have provided a new look at the historical experience of American industrial policy, showing how the role played by the US government regarding industrialization as driving the transformation of the economy in the long run have decisively contributed in promoting an American model of society.

In the fourth paper ("*Industry 4.0 policy from a socio-technical perspective: the case of the "Mittelstand 4.0" initiative in Germany*"), it was argued that the Industry 4.0 entails disruptions of the current dominant configurations at firm, industry and system level along three main dimensions of change: technological upgrading and digitization of production processes; business model and relations with customers; skill upgrading and novel organization of the workforce. In other words, the socio-technical transition towards the Fourth industrial revolution requires firms to combine – and continuously expand – their dynamic capabilities along these three levels of change, as a precondition to fully capture the economic value associated with upgraded manufacturing processes. Nevertheless, the occurrence of this transition remains uncertain and cannot be taken for granted. Therefore, Industry 4.0 policy initiatives may play a substantive role in steering firms' transition in these three dimensions, by enabling active and conscious mobilization of actors and means of production towards the creation of local and external linkages to get complementary expertise, knowledge and technologies. The analysis of the "Mittelstand 4.0" initiative in Germany has empirically highlighted how specific institutional arrangements and policy instruments put in place at various levels of the production system sought to avoid the fragmentation of Industry 4.0-related knowledge and technologies, which are mostly produced in research organizations, laboratories and universities scattered across the whole country, building unprecedented collaborative networks and mobilizing and pooling the existing knowledge on Industry 4.0. In particular, the role played by 'transition intermediaries' that are effectively rooted in local development systems (such as the German Competence Centres) can be extremely relevant in creating bottom-up and top-down interactions among different knowledge sources and actors and in coordinating competencies, expertise and resources necessary to foster Industry 4.0 processes.

In the fifth paper ("*The political economy of places in a Sustainable Human Development perspective: the case of Emilia-Romagna*"), it was argued that each local development system should be conceived as a social construction built on interactions among individuals and organizations embedded in multi-layered systems, which generate and manage conflicts, share knowledge and learn, take and implement individual, collective and local initiatives and thus shape the overall evolution of the system itself. An integrated industrial policy for sustainable human development at place level can thus be designed only when the inter-linkages between these dynamics and the variety and diversity of views, interests and ideas act as stimuli to avoid strict path dependence and lock-in, while setting a new shared vision for the structural change of the local economy and society. This must be pursued by overcoming traditional silos-based and sectorial policy, towards decision-making and operational arrangements based on a 'whole-of-government' approach, where synergies and coherence among policy areas are consistently leveraged towards a unifying vision. In a similar political economy framework, the

collective design and discussion of policies entails a real process of institutional change, which involves reshaping political incentives to favour participatory governance and whole-of-government mechanisms and gradually removing the most binding institutional constraints to economic development and social progress. The case-study of the Emilia-Romagna region is thus illustrative of how transformative changes towards sustainable human development can be made operational at regional level through an integrated industrial policy approach. Far from being a best practice as evidence of results and their attribution to implemented policies requires a longer time spam and different methodologies, it can be considered as a policy lab from, whose main principles for integrated industrial policy emerged in the empirical analysis are potentially adaptable to different settings and places facing similar challenges, according to contextual and conjunctural conditions and political willingness.

All in all, these papers contribute to the international debate by framing and showing that industrial policy is not just about targets and tools to pursue given objectives. Rather, it is about pursuing a normative societal vision and goals as defined by each specific community of people, groups, and interests in local and national societies, within the range of configurations compatible with systemic interest. Its scope can deal with industrial production, but also with other sectors (e.g. agriculture, services, construction) and complementary policy fields (e.g. research and innovation, education and training, social services); it can target specific sectors and firms, as well as regions, social groups or other relevant actors and networks; it may adopt a variety of policy tools, ranging from financial measures to new rules that modify incentives along with individual and collective behaviours.
In a nutshell, industrial policy should be conceived both as a technical and a political intervention to redesign and build better societies, favouring a structural transformation of industry, the economy, and society towards sustainable human development.
Therefore, the contribution derived from conceptualizing industrial policy within this perspective places emphasis on the structural analysis of industrial policy and collective action at local and national level, on the extent to which industrial policy is designed and implemented as a leverage for social progress, and on the extent to which it is able to make structural economic change socially and environmentally sustainable. It also illustrates the scale and nature of the complexities involved in framing industrial policy for sustainable human development, due to the importance of leveraging positive synergies through mutually reinforcing policy actions along with rendering trade-offs structurally non-obstructive as far as possible, in order to ensure that progress in industrial performances directly serve the public interest and it is not achieved at the expense of any wider societal goal.

To conclude, this collection of papers opens up a partially unexplored line of research, which requires a mutual engagement between theory and practice of industrial policy. Nevertheless, it is worth acknowledging some limits characterising the research presented in these papers. First, additional theoretical insights from other streams of literature dealing with industrial policy and sustainable human development may well fit and contribute to the arguments raised so far, such as economic geography, evolutionary and institutional economics, complexity theory and public management studies. Second, econometric modelling has not been applied to provide further evidence on industrial policy goals, targets and tools within a sustainable human development paradigm. Third, measurement and monitoring advancements accounting for the integrated notion

of sustainable development should be directly extended to shape new metrics on industrial performances at national and local level, in order to more consistently align analytical frameworks and measurement efforts. Finally, wider empirical evidence and insights would have surely emerged from case-studies related to emerging countries and international organisations, which have long devoted efforts to simultaneously upgrade industrial systems and tackle issues related to poverty, inequality and environmental degradation.

For these reasons, research on industrial policy for sustainable human development would potentially advance along four lines of investigation.

First, future research may further theoretical advancements in order to sustain integrated industrial policy for sustainable human development, placing the economic dynamics at the centre of processes of structural transformation of our societies at national and local level.

Second, future research may dig deeper into policy-making mechanisms and institutional settings allowing (or preventing) different values, interests and powers within national and local societies in both compromising on suitable weights to keep the system viable and reflecting a normative commitment to some definition of collective interest.

Third, future research may explore the connection between societal goals and strategic targets of industrial policy, as well as measure inclusive and sustainable industrial development performances within and between countries and over time, serving the need of policy-makers to strategically combine environmental, social and economic dimensions of sustainability based on a robust understanding of the real synergies and trade-offs among them.

Finally, future research may derive systematic evidence from a wide array of case-studies around the world and from comparative analysis on the design and implementation of industrial policies addressing sustainable human development challenges. Similarly, it may assess the effect of different industrial policy tools on wider societal goals and challenges through econometric modelling and (impact) evaluations of industrial policies on sustainable human development outcomes. In particular, a comprehensive mixed-methods research design appears promising to integrate theoretical insights with quantitative and qualitative methods (through parallel, sequential or iterative integration), in order to provide the academic and policymaking debate with deeper understandings of both processes underlying industrial policy design, implementation and governance as well as its outcomes in steering a sustainable structural change of our economies and societies.

These research lines will potentially pave the way for the diffusion of a new policy agenda dealing with the triple challenges of increasing value-added within production systems, combatting inequalities and exclusion and safeguarding the planet. Such policy agenda would support the formulation of public policies with the aim to consolidate the social value of institutions and, at the same time, it would support the generation of high value-added in local and national development systems, tackling collective needs and exclusionary processes and contributing to promote sustainable human development.

Therefore, it is also responsibility of scholars to actively support – and engage with – policymakers in setting industrial policies based on robust and transparent decision-making processes. In the Covid19 era, this

represents an element of highest concern in a world looking (and needing) for new theoretical bases to design and implement industrial policy for sustainable human development at all levels.

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