Industry 4.0 impact on management practices and economics (IN4ACT)

RESEARCH STRATEGY

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TABLE OF CONTENTS

Introduction 3

Part I: Thematic structure of the ERA Chair research strategy 5

Section 1: "Defining the Industry 4.0 field of investigation" 5

Section 2: "Conceptual Framework" 5

2. 1. "Technology as biology: beyond functionalism" 5

2. 2. "Globalization as a phase of "time-space compression" 6

2. 3. "The state and innovation: bringing "it" back in" 6

Section 3: "Structure and level of the research strategy" 7

Level I: "Micro-level: Industry 4.0 at the level of the firm, functions and phases of production" 7

I. 1. "The decomposition / re-composition of production and the rise of Global Value Chains (GVCs)" 7

I. 2. "Artificial intelligence, cloud computing, big data, algorithmic models, and the Internet of Everything" 7

I. 3. "The platform economy, its typology and economic specificity" 8

I. 4. "Platform economy business models" 8

Level II: "Meso-level: Industry 4.0 at the level of regions and regional innovation ecosystems" 9

II. 1. "Centralization vs. decentralization" 9

II. 2. "The changing economic geography and its implications for regional business ecosystems" 9

II. 3. "Commoditization and "smart specialization" 10

II. 4. "Symbiotic vs. parasitic ecosystems" 10

Level III: "Industry 4.0 at the level of governance, policy, regulation, and sustainability" 11

III. 1. "Comparative readiness for Industry 4.0: assessment and measurement methodologies" 11

III. 2. "The future of work: Industry 4.0 skillsets" 11

III. 3. "Industry 4.0 and socially inclusive development" 12

III. 4. "Governance: regulation, innovation and sustainability" 13

Part II: ERA Chair research strategy implementation Roadmap 16

Introduction

Industry 4.0, as a core aspect of what is increasingly referred to as the Fourth Industrial Revolution (henceforward 4IR), is a long-term systemic process that is bound to significantly affect the entire range of business management practices and economics regardless of the industrial sector in which firms are located as well as the social, regulatory, and institutional contexts in which they operate. Its implementation depends fundamentally on putting into place a wide-ranging set of “enabling framework conditions”. These range from technological infrastructures, standardization protocols across digitized systems, security / protection of knowhow, new business models, novel forms of work organization, new and often unforeseeable skillsets, and governance, legal and regulatory frameworks at regional, national and EU levels. In addition, the implementation of Industry 4.0 will require sustained engagement with and buy-in from all key stakeholders across private and public spheres. In other words, the realization of the potential of Industry 4.0, as well as the mitigation of its potentially harmful and destabilizing consequences, is dependent on the reconfiguration of existing structures of production, civil society and public administration.

In this context, the ERA Chair research strategy outlined in this document seeks to extend beyond traditional research and scientific disciplinary boundaries. On one hand, this involves the adoption of an interdisciplinary perspective transcending conventional forms of academic specialization; on the other, it demands sustained engagement with stakeholders and social actors beyond the boundaries of academia and research, i.e., systematic engagement with the worlds of business, civil society, and institutions of governance, policy and regulation and different levels of public administration. This is the methodological principle underlying the ERA Chair research strategy.

The overarching organizational principle of the strategy is that Industry 4.0 and the possible futures it holds is not a historical inevitability. The clusters of technologies associated with the current transformations in economy and society do not in themselves point to a “direction”. Instead, they represent a “potential” whose realization and actual implementation will be determined by the exercise of social and political options. It is the broad adoption of these options – or lack thereof – that will condition the likelihood of the realization of any given future Industry 4.0 trajectory – but also its capsizal. The main argument here – the hypothesis to be tested through empirical research – is that these options will be shaped by the dynamic interactions of three forces: *technological advances* and the specific ways they will be deployed across economy and society; the future of *globalization*, specifically the degree of its compatibility with socially and environmentally sustainable development; and the role of the *state*, specifically in mediating and taking an active role in the creation of “enabling frameworks” for the diffusion and adoption of the technologies, the management of globalization, and their collective disruptive and destabilizing consequences for economic and social systems. The realization of the potential of Industry 4.0 and the 4IR itself, like in previous industrial revolutions, in other words, requires the formation of a “direction”.

For researchers and policy-makers the key point to be taken from this is that this direction is neither pre-determined nor automatically given by the technologies involved. Historically such direction has been the result of an “enabling framework” that has been typically marked by the constellation of lifestyle-shaping goods and services made possible by the new technologies; the ability of entrepreneurs, investors and governments to recognize the potential of these products; the political ideologies of those with the power to sustainably affect deployment and infrastructure development and shape the socio-historical context in which they emerge in ways that facilitate broad societal acceptance and adoption.

Given the scale, breadth, and systemic nature of the process of transformation associated with Industry 4.0, the ERA Chair research strategy is structured around three operational levels that leading international research considers as having a decisive influence on future prospects of Industry 4.0: the *micro-level* (the level of the firm), the *meso-level* (regional economic and innovation ecosystems), and the *macro-level* (systems of governance, policy, regulation, and sustainability). The research streams on each of these levels are organized into sub-streams of specialized research domains. These streams should be considered as conceptual orders, not as actually existing compartments, since any of the identified research domains under any specific stream is likely to be in interaction with, and influenced by, other areas under different streams. For each of these streams the document provides an indicative list of literary references, that is, leading international research and literature currents to be systematically engaged by the IN4ACT ERA Chair team and integrated into the research portfolios of the Research Groups and faculty of the Kaunas University of Technology School of Economics and Business (see Appendix). In this respect, the research strategy is designed to function as a “living” document (to be regularly updated throughout the duration of the project) whose purpose is to map the broader field of the currents of scientific research and literature, as well as the current and debates surrounding Industry 4.0, and function as a roadmap to their key issues.

The thematic structure of the strategy is organized around three sections. The first (Section 1) addresses the historical specificity and key characteristics of Industry 4.0 and the broader context of the 4IR. The second (Section 2) addresses the conceptual issues and challenges involved in capturing and analyzing the key drivers and business, management, policy /regulation, and broader societal implications of Industry 4.0. The third (Section 3) lays out the structure and levels of research subdivided into specific substantive issue domains to be addressed during the implementation of the research strategy. What follows is an overview of each of them.

Part I: Thematic structure of the ERA Chair research strategy

Section 1: "Defining the Industry 4.0 field of investigation"

This section is concerned with the main aspects of the field of investigation by focusing on selected key elements of Industry 4.0 and the 4IR. The purpose here is to develop an anatomic view of the structural features and drivers of Industry 4.0. Much of the current discussion tends to identify the 4IR with the German government's Industry 4.0 initiative to create a coherent policy framework to maintain Germany's industrial competitiveness and related strategic programs across the globe. However, though Industry 4.0 is central to – and for some, the hard core of – the 4IR, the latter involves a broader and more encompassing systemic transformation that has a wide range of impacts on civil society and the institutional structures of governance, in addition to its economic and manufacturing ramifications.

Academic definitions and arguments over historical periodization, needless to say, abound and even though most might consent that "something big is on the horizon" not everyone would agree to call it a 4IR. The section seeks to place the current transformation in historical context in order to delineate the historical specificity of Industry 4.0. The First Industrial Revolution spanned the decades from about 1760 to around 1840. Set in motion by the construction of railroads and the invention of the steam engine, it ushered in mechanical production, the beginning of what some call "the first machine age". The Second Industrial Revolution, which originated in the late 19th century and ran into the early 20th century, was marked by mass production that was fostered by the advent of electricity and the assembly line epitomized in Fordism. The Third Industrial Revolution began in the 1960s. It is usually called the "computer" or "digital" revolution because it was spearheaded by the development of semiconductors, mainframe computing (1960s), personal computing (1970s and 80s) and the internet (1990s).

The origins of Industry 4.0 and the 4IR can be traced to the beginning of this century and build on and amplify the impact of the digital revolution. So why not call it a more intense phase, a phase of maturation, of the computer or digital revolution? There are mainly three reasons why not: 1) *Velocity and scale*: In contrast to previous industrial revolutions, Industry 4.0 and the 4IR itself have the potential to evolve at an exponential rather than linear pace; 2) *Breadth and depth*: Industry 4.0 builds on the digital revolution and combines multiple technologies from across various fields that have the potential to lead to unprecedented paradigm shifts in established practices in the domains of business, the economy, and society; 3) *Systemic Impact*: Industry 4.0 presents a real possibility of transforming entire systems, across and within countries, companies, industries and civil society as a whole and the structures of the state.

Section 2: "Conceptual Framework"

This section addresses the conceptual framework and the "anchor" concepts of the research strategy. The main objective here is to identify the ways in which the transformations associated with Industry 4.0 necessitate some rethinking and readjustment of the conceptual triad of *technology*, *globalization*, and the *state*.

2. 1. "Technology as biology: beyond functionalism"

In terms of *technology*, the research undertaken in this sub-stream is largely based on the argument that today we need to move beyond "functionalist" understandings of technology – technology as a "tool" – and toward more synthetic evolutionary conceptions. Novel technologies arise by combinations of existing technologies, through a process of *combinatorial evolution*. In the present context of technological development, as we adopt and use new technologies, we are moving from using nature to intervening directly within nature. We are entering a period where, conceptually at least, biology itself is becoming technology, and physically, technology is becoming biology, an open “living system”. But as the technological combinatorial evolution of the economy intensifies it introduces new operating principles into the foundations of economic systems. In the process, modelled order, closedness, and equilibrium as ways of developing economic explanations are being replaced by open-endedness, indeterminacy, and perpetual novelty. This has additional implications for our understanding of the controversial nature and status of information in the “information economy” and the instability associated with the seemingly inexorable drive toward novelty: for, on the one hand, products and services can be understood as physical orders, the “crystallizations” of structured information and knowhow, yet, on the other hand, information tends to destabilize markets and corrode the normal operation of the market mechanism. For once you move to an information economy, the market mechanism for setting prices tends to drive the marginal cost of certain goods, over time, towards zero – eroding profits in the process.

2. 2. “Globalization as a phase of “time-space compression”

Regarding *globalization,* the argument underpinning this sub-stream is that the transformation of space and time in the human experience is one of the central characteristics of all major social transformations. Far from signifying the “end of geography” globalization entails a further diminution in the friction of distance through an intensified round of innovation in information and communication technologies (ICT) and the technologies of transport and logistics. However, the collapse of spatial barriers associated with the globalization of production and finance, does not mean that the significance of space is decreasing. In fact, the opposite is true since geographical location remains a critical aspect of economic activity. Heightened competition, especially under conditions of crisis, leads companies to paying much closer attention to relative locational advantages because diminishing spatial barriers enable them to exploit minute spatial differentiations in the cost / benefit landscape. However, though it is important to remain focused on the quantitative aspects of globalization (levels of economic integration, velocity of financial transactions, volumes of international trade etc.), it is equally important to focus on its qualitative aspects. This means adopting a perspective that grasps globalization as a phase of “time-space compression” that has given rise to the contested and uneven development of a system of planetary (geographical) and digital (spatial) reach that has the technological, organizational, institutional and decision-making ability to act as a coordinated system in real or chosen time. This is at the core of globalization and the social and economic dynamics driving Industry 4.0 and its evolution will have a decisive impact on any development trajectories.

2. 3. “The state and innovation: bringing “it” back in”

With respect to the role of the *state* in innovation, the rationale underpinning this sub-stream is that it is high time to dispense with the popular mythology that innovation is a phenomenon set in motion exclusively by entrepreneurs, startups, and garage tinkerers under the encouraging eye of the state. Recent research indicates that at the very least since World War II the state has been a – if not the – decisive force behind all the major innovations of our time, not only in organizing the “enabling frameworks” that foster innovation but also undertaking the necessary high-risk greenfield investments that private business, and certainly venture capital, typically would forgo. What’s more, the state, especially in the United States, where most of the post-war leading technologies trace their origins, has taken not only an active role in the development of critical technology fields under its various guises – be they the “Hidden Developmental State”, the “National Security State”, or the “Entrepreneurial State” – it has also taken an active role in building the physical environments, what have been called “cities of knowledge”, that is synergistic constellations of leading educational and research institutions, private companies, and state (especially military) active presence in infrastructure, financial and military-grade technological compliance support, within which innovations have been developed. This is why, the ability – or inability – of the state to provide a socially and environmentally sustainable “direction” will have a decisive influence on the future trajectories of Industry 4.0 and the 4IR itself.

Section 3: "Structure and level of the research strategy"

This section lays out the structure and levels of research subdivided into specific priority substantive issue domains.

Level I: "Micro-level: Industry 4.0 at the level of the firm, functions and phases of production"

This level concentrates on Industry 4.0 as it is encountered at the micro-level – the level of the firm, and more precisely on the geographically distributed functions and phases of production.

I. 1. "The decomposition / re-composition of production and the rise of Global Value Chains (GVCs)"

The objective of this sub-stream is to examine the process of decomposition / re-composition of production, along its functional and geographical dimensions, and the formation of GVCs. While GVCs may not be an entirely new phenomenon, they are a defining feature of the current phase of modern globalization. Particularly new are the speed, scale and complexity they add to the process of economic globalization. GVCs are the central matrix of the global restructuring of production and constitute one of the key foundations of the emerging "platform economy". The emergence of GVCs and production networks mean that the relevant unit in economic analysis is no longer the industry or sector but the "business function" or "activity" along the supply chain. Countries, regions and companies increasingly tend to specialize in specific business functions or activities rather than specific industries. The rise of GVCs illustrates why specialization no longer takes place solely in industries but in specific functions or activities in the value chain. And it is around such functions and activities that global competition is increasingly organized in the context of Industry 4.0.

I. 2. "Artificial intelligence, cloud computing, big data, algorithmic models, and the Internet of Everything"

The purpose of this sub-stream is to explore the significance and implications of artificial intelligence, cloud computing, big data, algorithmic models and the Internet of Everything. If GVCs are reconfiguring the "where" of production / services, big data, algorithms, the cloud, and the Internet of Everything are redefining the "how". Their integration into the production process is transforming the structure of the economy and the nature of work by facilitating the growth of the platform economy. Computing power is increasingly converted into economic tools using algorithms that operate on vast reservoirs of the raw material of big data. At the same time, the Internet of Everything signifies a transition from a period where the types of products that were produced were mechanical – made manually through various value-chain activities – to one where products and production itself are becoming "smart". The transition has evolved through successive waves of ICT: value chain automation (1960s and 1970s); value chain dispersion and integration (1980s-1990s); smart, connected products (today). A product becomes "smart" when technology, such as a sensor, is embedded in it; it becomes "connected" when it is connected to another product. Smart, connected products enable new categories of capabilities and new types of functionalities. These include: monitoring, control, optimization, and autonomy. Unlike the previous waves of ICT transformation that boosted firm productivity, this one will affect companies' strategies and how companies differentiate themselves, create value, and compete, and will change the structure of industries. Taken together, artificial intelligence, big data, algorithmic models, and the Internet of Everything embody considerable transformative potential as they are changing the basis of competition, redrawing industry boundaries and creating openings for new waves of disruptive companies just as the current internet has given rise to the likes of Amazon, Google, Uber, Airbnb, and Netflix.

I. 3. "The platform economy, its typology and economic specificity"

The goal of this sub-stream is to explore the emergence and typology of the platform economy and its economic and business implications. While the Third Industrial Revolution saw the emergence of purely digital platforms, a central characteristic of Industry 4.0 and the 4IR is the rise of global platforms that are structurally connected to the physical world. Platforms are hybrid structures of software, hardware, operations, and networks. Their key aspect is that they provide a set of shared techniques, technologies, and interfaces to a broad set of users who utilize the capabilities offered by platforms to build what they need. Many of these platforms attract large crowds of other contributors that can result in the formation of an ecosystem. A fundamental feature of platforms is the presence of "network effects": as more users engage with the platform, the platform becomes collectively more valuable and attractive to potential new users. This is one of the main reasons why some platforms have experienced viral growth, reflected in stratospheric market capitalization values. At the same time, platform enterprises have been disruptive as they have upended numerous brick-and-mortar chains and are making deep inroads into other traditional industries. By embracing the transformational power of platforms, enterprises across all industries are capturing new growth opportunities and changing the way they do business. And it is these new business models and the ecosystems being built around them that are driving a profound change in the global macroeconomic environment. For platform ecosystems constitute the foundation for new value creation in the digital economy. The sub-stream, in this context also explores the typology of platforms and their significance for competition, disruption of established business practices, and the possibility of the emergence of a "winner-take-all" economy.

I. 4. "Platform economy business models"

This sub-stream examines the defining characteristics of the platform economy business model and its variations. The business model that dominated much of the postwar industrial era was centered on the corporate imperative for growth, scale, vertical integration and hierarchy attached to "job ladders", it was asset-heavy, and its performance was measured by industrial "territory" and market "footprint". The platform economy consists of enterprises with a variety of business models targeting a wide range of market segments (e.g., social media, travel, music, transportation, banking, healthcare among others). There are, however, certain key common elements to them. The platform economy business model is centered on finance – not just the presence particular financial institutions in it, but finance as a model of "how things are done". This is related to the wider financialization of the economy (even though unevenly developed across different countries and regions) that has accompanied the ICT advances since the 1980s. Financialization refers not just to the preponderance of the financial sector in the economy, but also the broad institutionalization of its logic throughout the economic system and the elevation of stock performance to the key performance indicator (often artificially boosted through "share buybacks"), encapsulated in the primacy of "shareholder value" and the preference for financial investments over productive assets. As a result, even though with variations across different domains, the dominant business model of the platform economy is "ICT-and algorithm-heavy", "finance-heavy" in the sense that company "size" relates predominantly to market capitalization value, "asset" and "labor-light" (minimal employment commitments and the effective disappearance of 'job ladders') and oriented toward market capture in the form of monopoly (Google, Facebook) or monopsony (Amazon). In this context, the sub-stream also examines the ramifications of the platform economy business model for the rest of the "old" economy with specific emphasis on what has been called "Nikefication", that is, the conversion of the corporation into a nexus-of-contracts, organizationally separating design from production and distribution. The key characteristic of the model, is emphasis on high-value phases of the production process, intellectual property, design, and brand and contract out to other organizations traditional control of production and distribution – it is the "invented here", but "manufactured there" practice exemplified by Nike and Apple among many others.

Level II: "Meso-level: Industry 4.0 at the level of regions and regional innovation ecosystems"

This level explores the effects and implications of Industry 4.0 as they are encountered at the level of regional economies and innovation ecosystems.

II. 1. "Centralization vs. decentralization"

The objective of this sub-stream is to explore the sets of challenges and opportunities arising from Industry 4.0 and the platform economy for regional economies and innovation ecosystems. These hinge on whether "domain expertise", that is deep knowledge about a single industry, which tends to concentrate in specific cities or regions, will continue to hold competitive advantage in the foreseeable future. One issue of fundamental importance, in this context, concerns the dynamics of centralization vs. decentralization associated with Industry 4.0 and the platform economy and their locational implications for existing as well as emerging industries. Two questions orient the research. First, are existing concentrations of advanced computing power, cloud scale, access to big data and algorithmic expertise likely to lead to further concentration of economic power organized around places like Silicon Valley? If the answer is positive, the prototype already exists. It is Uber, the ride hailing platform. Uber had no particular expertise in transportation but that did not matter much because of its ability to build a software and analytics platform transferring wealth from the owners of taxi companies and owners all over the world to Uber shareholders in what some liken to payment of tribute to an emperor. Multiply this across different sectors and the magnitude of the challenge speaks for itself. Second, will the growth of big data become sufficiently usable and scalable so instead of absorbing and supplanting other industries, serve as a broad tool that every existing industry can use to spur growth and revitalization for old industrial centers where local domain expertise exists? If the answer here is positive, then there are reasons to be optimistic about the prospects for big data firms developing outside the United States. In such a scenario of "domain expertise is everywhere" the only challenge would be to combine algorithmic expertise and domain expertise.

II. 2. "The changing economic geography and its implications for regional business ecosystems"

The purpose of this sub-stream is to research the impact of Industry 4.0 on urban economic geography. Recent research indicates that the technologies and economic activities Industry 4.0 and the 4IR bring in their path are reshuffling the ranks of cities and regions across the globe. The dominant trend is concentration. Indeed, the extent to which economic activity has become concentrated in the world's cities and metropolitan areas is astonishing. The fifty largest metropolitan areas across the globe house just 7% of the world's total population but generate 40% of global economic activity. Just forty mega-regions – constellations of cities and metros like the Boston-New York-Washington corridor – account for roughly two-thirds of the world's economic output and more than 85% of its innovation, while housing just 18% of its population. Even though it is probably too early to confidently predict specific patters of change, research shows that as capitalism's spatial division of labor – the distribution of economic activities across geographical locations – becomes more finely honed, fewer and fewer cities are able to hold on to the most economically valuable activities and niches. The most highly prized talent and skill and the most profitable high value-added industries, which used to be spread across many medium-sized and smaller cities, increasingly concentrate in a few superstar cities. The result? Alpha cities, the apex, like New York and London (the latter remains to be seen after Brexit). Beta, second tier, cities such as Tokyo, Hong Kong, Paris, Singapore, and Los Angeles. The rest, Seoul, Vienna, Stockholm, Toronto, Chicago, Zurich, Sydney, Frankfurt, Barcelona, Milan, Helsinki, Dublin, and so on, occupy a third tier, functioning as important regional financial and economic nodes with key global functions. San Francisco, Boston and Washington DC play additional roles as specialized knowledge and technology hubs.

II. 3. “Commoditization and “smart specialization”

This sub-stream seeks to explore the reverse side of this: the process of commoditization and the responses to it, that is, strategies of “smart specialization”. If the highest portions of the GVCs lead to concentration and centralization of high value-added activities, anything below is becoming subject to varying degrees of commoditization. The decomposition of manufacturing and services, outsourcing, and the spatial distribution of production activities around the globe, coupled now to the integration of cloud computing, big data, algorithmic models and the Internet of Everything in the productive process have unleashed a process of commoditization across the countries of advanced capitalism. The functional and geographical decomposition / re-composition of production and services has been accompanied by the dispersion of skills and knowhow to competing geographical locations undermining in the process regional clusters of capacities in the advanced countries as similar clusters have been built elsewhere. The result? Increasing difficulty of value-added differentiation in the GVCs, price-based competition throughout markets for standard goods and services, and pressure on wages and profit margins alike, not only for companies but for entire regional economies and innovation ecosystems across advanced countries.

It is largely against this background that “smart specialization” emerged as a key concept and policy agenda for science, technology and innovation in the Europe 2020 strategy and across other OECD economies. The underlying rationale of the smart specialization concept is that by concentrating and clustering knowledge resources and linking them to a limited number of priority economic activities, countries and regions can become – and remain – competitive in a world economy defined by GVCs. It allows regions to take advantage of scale, scope and spillovers in knowledge production and use, which are important drivers of productivity. In short, smart specialization is about generating and capitalizing on the unique assets and capabilities of a region’s distinctive industrial structures and knowledge bases. It is about a new generation of research and innovation policy that goes beyond the classical investments in research and technology, and general innovation capacity-building. A key question here – probably of an existential nature for some regions – is: is smart specialization likely to provide a sustainable counterweight to the “expertise domain” agnosticism of the platform economy exhibited by the likes of Uber or Amazon?

II. 4. “Symbiotic vs. parasitic ecosystems”

The purpose of this sub-stream is to critically examine the adequacy of smart specialization as a framework supporting sustainable innovation in the context of Industry 4.0. The main point here is to differentiate among modes of financing innovation and distinguish between “symbiotic” and “parasitic” ecosystems. First, smart specialization stresses, correctly, that innovation is an ecosystem phenomenon. However, it does not specify the exact role each actor plays in the risk landscape of innovation. Many errors of current innovation policy are due to placing actors in the wrong part of this landscape – both in time and space. For instance, is venture (private) capital the appropriate form of finance for all types of emerging technologies that power innovation? Or is it the case that “patient” (public) investment is more appropriate in some critical technology areas with longer maturation and innovation cycles?

Second, how can smart specialization ensure that increased investments by the state in an innovation ecosystem will not result in the private sector investing less, and using its retained earnings to extract short-term profits, say through “share buybacks”, instead of in riskier areas like human capital formation and R&D, to promote long-term growth? This raises the question of whether the “open innovation” model adopted by the European Commission as a way to foster innovation is becoming dysfunctional. Why? Because, as large companies are increasingly relying on alliances and collaborations with SMEs and the public sector within regional innovation ecosystems, the indication is that large players invest more in short-run profit gains than long-run investments. In this context, the sub-stream explores the different conditions that mark innovation ecosystems that foster a “symbiotic” relationship between public and private sectors from ones that foster a “parasitic” one.

Level III: “Industry 4.0 at the level of governance, policy, regulation, and sustainability”

This level concentrates on the impact and ramifications of Industry 4.0 and the 4IR as they are encountered at macro-level, that is the state, innovation policy and regulation, employment and skills, the issue of inequality, and governance frameworks.

III. 1. “Comparative readiness for Industry 4.0: assessment and measurement methodologies”

The objective of this sub-stream is to research how countries across the EU and internationally respond to the management and policy challenges presented by Industry 4.0 and their strategies to leverage production as a national capability. This requires countries to first understand the factors and conditions that have the greatest impact on the transformation of their production systems and then assess their readiness for the future. Subsequently, governments – together with industry, academia and civil society – can take suitable policy actions to close existing gaps related to their readiness for the future of production. In this context, the sub-stream examines international comparative readiness for Industry 4.0 by applying and elaborating on the *Readiness Diagnostic Model Framework* developed by the World Economic Forum, as well as other leading international assessment methodologies. Readiness is generally regarded as the ability to capitalize on future production opportunities, mitigate risks and challenges, and develop resilience mechanisms and agility in responding to unknown future shocks. The assessment is made up of two main components: “structure of production” (complexity and scale), or a country’s current baseline of production, and “drivers of production” (technology and innovation, human capital, global trade and investment, institutional framework, sustainable resources, demand environment), or the key enablers that position a country to capitalize on Industry 4.0 to transform production systems.

III. 2. “The future of work: Industry 4.0 skillsets”

The main objective of this sub-stream is to research the impact of the technologies and business models associated with Industry 4.0 on employment and skills. Future development trajectories of Industry 4.0 will be shaped in important ways by the impact of technological and economic change on the formation of appropriate skillsets and sustainable employment. Research shows that the global labor share of national income has been in decline since the early 1980s, and this is occurring within the large majority of countries and industries. It has to do, partly, with the decline of the relative price of investment goods. Efficiency gains in capital-producing sectors, often related to advances in ICT, induced firms to shift away from labor and toward capital to such a large extent that the labor share of income declined. This pattern seems to have been reinforced in the post-2008 period where the dominant trend has been stagnant rates of unemployment, an outlook which according to official estimates will continue to deteriorate in the coming years.

Indeed, according to some estimates close to half of existing jobs, especially “routine” jobs subject to automation, are at high risk of disappearing in the next decade or two. Underpinning some of these developments is the decline in medium-skilled routine jobs in recent years reflected in the polarization of skills in demand and labor market dynamics, the parallel but uneven growth of “mcjobs” and “macjobs” across the OECD countries, effectively leading to the hollowing out of middle-class jobs. While few occupations are fully automatable, 60% of all occupations have at least 30% technically automatable activities. At the same time the emergence of the platform economy and corporate disintegration through “Nikefication” undermine occupational mobility because by contracting out "non-core" jobs, these jobs become separated from the ladders that once offered a means to move up within an organization. Outsourcing traditional entry-level positions, as a result, tends to leave the holders of these positions stranded without an obvious path for promotion.

This is one aspect of a deeper fragmentation of the labor process itself. This involves a shift from the "death of the career" and its replacement by "jobs" with employees often moving from firm to firm, or working as independent – a pattern that originated in the 1990s – to a shift from jobs to "tasks" to be performed under task-oriented contracts – a key feature of the platform economy and a pattern observable in several industries today. Again, Uber, among many other platform enterprises, provides a good case of what "labor-light" means. As of June 2017, Uber had roughly 6 thousand employees but 1 million "driver-partners" in over 570 cities worldwide. Some analysts argue that the most important thing about Uber is not what it is doing to the taxi industry – effectively becoming a transfer mechanism of income from taxi companies and taxi owners to its shareholders. The most important thing is what Uber and other platforms do to labor markets and how employment is organized. Platforms like Uber make it easy to create a spot market for all kinds of labor. Someone needing a work crew for the day could post a virtual sign-up sheet, and potential contractors with the relevant skills could bid against each other to be in the first, say, five slots. Those who "won" would find their own way to the worksite. This is what is meant by "labor-light" economy: the morphing of the labor market into a "human cloud" in which jobs are completely decomposed into tasks that are staffed on demand (a process often referred to as "Uberization"). This is the pathway to the "precariat", with rampant markets and pervasive economic uncertainty. And, of course, tasks, to the extent that they can become codified and programmable, are subject to outsourcing and offshoring, labor competition on price and, depending on relative costs of labor vs. technology across different markets, subject to automation.

But this, placed in the wider context of what has been called "the second machine age" – an era where computers and other digital "learning machines" do for mental power what machines did for muscle power during the industrial era – along with the growth of "cloud robotics" – the migration of much of the intelligence that animates mobile robots into powerful, centralized computing hubs – raises a fundamental question: what is an Industry 4.0 "skillset" and what exactly is the role of education in forming it? For recent research shows, that over the past several years, there has been a "great reversal" in the demand for skills and cognitive tasks in labor markets where graduates prepared for "macjobs" are being forced to take on "mcjobs" (e.g., software engineers, and even lawyers and other highly skilled graduates working as baristas at Starbucks or "driver-partners" for Uber). The key issue here is whether or not acquiring more – as well as what kind of – education and skills will offer effective protection against "Uberization" and job automation in the future. What exactly is the purpose of a college or university degree in a labor world centered mostly on the performance of "tasks"? Is education itself – in the sense of applied skills acquisition – becoming commoditized, essentially a self-perpetuating jobs machine for the credentialed? Is this then driving what has been called "educational credentials inflation", that is a rise in the educational requirements of jobs that is not commensurate to the knowledge and skills required for the performance of tasks?

III. 3. "Industry 4.0 and socially inclusive development"

Research undertaken under this sub-stream concentrates on Industry 4.0 and its implications for inequality and social exclusion. Both have been consistently identified by most observers and analysts as a major force of potential destabilization that could challenge and even reverse globalization in its current form but also the prospects of Industry 4.0 and the 4IR for the next decade. Indeed, inequality across the OECD, let alone the world at large, by some estimates, is reaching levels not seen since the French Revolution. According to recent research, the group of billionaires and millionaires who comprise 1% of the global population control 45% of total global wealth, while 3.4 billion individuals – or 71% of adults worldwide – have wealth below USD 10,000. By 2014, in the United States the six Walmart heirs together had more wealth than the bottom 42% of Americans combined (up from 30.5 percent in 2007). Similar trends, though not as pronounced, are underway in the European Union. Inequality is intimately related to the specific ways technology is deployed across economic systems and the prevailing systems of wealth distribution, which is a question of political economy, not one of economics alone. More precisely, it is the specific ways technological change and technologically-enabled globalization have evolved, coupled to the return to a political economy regime since the 1980s, where the rate of return on capital significantly exceeds the growth rate of the economy (r > g inequality) that account for the current levels of inequality. Why? Because, taken together they tilt the scales of wealth and national income distribution in certain ways and not others, specifically increasing the rate of return on capital in relation to the rate of growth. And when the rate of return on capital significantly exceeds the growth rate of the economy then it logically follows that inherited wealth grows faster than output and income. People with inherited wealth need save only a portion of their income from capital to see that capital grow more quickly than the economy as a whole.

At the same time, these growing levels of inequality are being etched into a new class geography reflected in real estate market indicators and what has been called the “new urban crisis”. As was mentioned above, the concentration of talent and high valued-added economic activities in fewer and fewer places divides the world’s cities into winners and losers. It also means that winner cities become unaffordable for all but the most advantaged. This is great news for wealthy landlords and homeowners, but bad news for almost everyone else. Simply put, land and real estate owners in expensive superstar cities and tech hubs within them have been capitalism’s biggest winners. Exclusive penthouses, luxury townhomes, and other conspicuous real estate holdings amount to the geographic manifestation of the r > g inequality. In the process, gentrification is becoming the dominant urban manifestation of the new class geography across much of the advanced capitalist countries. What are being already referred to as “urban rentiers” have more to gain from increasing the scarcity of usable urban space than from maximizing its productive and economically beneficial uses. The end result is the rise of what has been dubbed the “parasitic city”, in which wealthy homeowners and landlords capture a disproportionate share of economic output and wealth. Parallel to these trends is another more insidious process – the deepening sorting and segregation by income, education, and class. This pattern of inequality and economic segregation, though more prominent the United States, is also emerging in many European cities.

III. 4. “Governance: regulation, innovation and sustainability”

The research organized under this sub-stream explores emerging issues related to governance. The broad changes brought about by digital technologies and the pervasive effects of big data and the algorithmic models that manage them are giving rise to major challenges for institutions and governance structures of the economy and society. Secret and proprietary algorithmic models are beginning to govern human behavior in increasingly larger areas of economic, social and, indeed, political life (a phenomenon increasingly referred to as “algorithmocracy”). These range from domains such as going to college, finding and holding a job, borrowing money, getting insurance or getting sentenced to prison, and, as evidenced recently, manipulation of electoral campaigns and the political process itself, not only within countries but also across them. Algorithmic models, despite their reputation for impartiality, reflect goals and ideology. The fundamental question for each domain of their operation is not only who designs these models but what the designer’s – be that an individual, a company or a state agency – objectives are. The sub-stream, in this context, explores current debates in this front in the areas of competition and anti-trust regulation, labor and consumer protecintertion, and global governance regarding big data and the platform economy.

Debates regarding regulation have already begun and battle lines are being drawn. For instance, with respect to anti-trust policy some are calling for the break-up of the likes of Google and Amazon by extending and adapting anti-trust regulation. But traditional anti-trust policy will most likely need a more comprehensive reach. For the breakup of the dominant platform players would not stop network effects from reasserting themselves: in time, one of the new smaller ones would become dominant again. Nevertheless, regulatory authorities, at a minimum, will have to sharpen their tools in the context of Industry 4.0 and the 4IR. There is accumulating evidence that "super-platforms" wield too much power and their superior technological capabilities, access to data and advanced algorithms facilitate price manipulation and discrimination through tacit collusion. With greater quantities of data of superior quality than other competitors have, they can quickly detect competitive threats. Their deep pockets allow them to buy start-ups that could one day become rivals (e.g., Facebook buying WhatsApp because of its alternative and potentially threatening "social graph", the network of connections between friends, which is Facebook's most valuable asset). They can also manipulate the markets they host by, for example, having their algorithms quickly react so that competitors have no chance of gaining customers by lowering prices. The reality is that we have entered an era where the invisible hand is being replaced by a highly programmable and longer "digital hand".

In other words, the algorithmic models that power the platform economy and the infosphere challenge the boundaries and operational efficiency of traditional forms of regulation. Code, it has been said, is law. For it embodies binding restrictions on behavior. Algorithmic models and platforms structure and shape behavior according to the objectives built into them. Traditional forms of regulation and the law as it is written in the legal texts are often difficult to apply or enforce in the digital world where action is possible only if it conforms to frameworks inscribed in the code that shapes and directs behavior. Government regulation will influence how the new technologies are deployed and their consequences, but in a platform economy, government decisions may be constrained by the "rules" in the software. Moreover, big data and algorithmic models are proprietary components of corporate strategies, which raises additional legal, regulatory and policy challenges regarding the ownership and uses of data.

At the same time, a more equal geographic distribution of the value extracted by algorithms from data may be even more difficult to achieve. Currently, most big data refineries are based in the United States or are controlled by American firms. As the data economy progresses, this does not seem sustainable. Past skirmishes between the United States and the European Union over privacy most likely give a taste of things to come. In China draft regulations require firms to store all "critical data" they collect on servers based in the country. Conflicts over the control of oil – the fuel of the industrial era – have scarred the world for decades. Even though it is difficult to delineate the battlefield, the data economy has the same potential for international and cross-regional confrontation.

But the issue of governance, in the context of Industry 4.0 and the 4IR, is broader than reforming and updating anti-trust and competition policy. As Tim Berners-Lee has warned recently, the challenges facing the web go directly to the heart of the status and sustainability of democracy, for they concern three issues: control of our personal data; challenges to the veracity of information and the easiness of spreading misinformation and "alternative facts", and lack of transparency and understanding of online of political advertising. For instance, the growth of micro-targeting in political campaigns – customizing political messages to target individual political profiles – is making hard for us to access the political messages our neighbors and fellow citizens are seeing – and as a result, to understand their political beliefs and reasoning. It also allows the same political personality, political party, or message to be many things to many different audiences. Dealing with different parties separately so that none of them knows what the other is hearing is a common tactic used in business negotiations and police interrogations. This asymmetry of information – the opaque and unaccountable science of micro-targeting – prevents the formation of a common understanding of a given issue and undermines the capacity of various parties to join forces to confront it – which is precisely the point of a democratic system of governance.

This is why, traditional forms regulation will soon need to be algorithm-enabled or equipped with distinct capabilities of algorithmic reverse engineering. The *Web Transparency and Accountability Project* at Princeton University is perhaps a sign of things to come. The project creates software robots that masquerade online as people of all stripes – rich, poor, male, female, or suffering from mental illness. By studying how these robots are treated, the project researchers are able to decode and detect the biases – the objectives – built into algorithmic models behind automated systems from search engines to employment posting sites.

At the moment, one thing seems certain: in the absence of a regulatory and governance regime of these or similar capabilities we are likely to enter a pervasive and highly intrusive monitoring practice that can lead to a system akin to a global “panopticon”. The “panopticon”, in its classic architectural design, first introduced by Jeremy Bentham in the 19th century and further elaborated by Michel Foucault in the 20th, was paradigmatic of several 19th century “disciplinary” institutions. It is a circular prison, where individual cells are built into the circumference of the building around a central well. A warden observes the cells from an inspection tower that stands in the center, and while the cells are lighted and transparent, the tower is dark. This creates a situation where the warden can closely monitor the activities of multiple prisoners. The prisoners know that they are always visible, but do not know when they are actually being watched. This aspect is central to the panoptic structure: those inside the panopticon, says Bentham, “should always feel themselves as if under inspection, at least as standing a great chance of being so”. Foucault elaborates this argument, proclaiming that “the major effect of the Panopticon [is] to induce in the inmate a state of conscious and permanent visibility that assures the automatic functioning of power”.

Part II: ERA Chair research strategy implementation Roadmap

This section outlines the ERA Chair strategy implementation Roadmap. Based on the thematic structure of the strategy its implementation is organized around the following principles and action streams:

- *Internationality:* systematic engagement of the ERA Chair team and the KTU School of Economics and Business faculty and researchers – especially the four Research Groups of the School: *Innovation and Entrepreneurship*, *Digitization*, *Sustainable Economy*, and *Sustainable Management* – with leading international research currents on Industry 4.0 and related subjects;
- *Interdisciplinarity:* development of interdisciplinary research directions in collaboration with external researchers of diverse research and scientific backgrounds to be assembled according to specific research projects and objectives in ways that facilitate the integration of key aspects of Industry 4.0 into existing and emerging School research portfolios;
- *Maximum relevance through sustained stakeholder engagement:* development and management of external Industry 4.0 stakeholder relationships – especially across the business and policy-making communities in Lithuania and across the EU – in order to build relations of trust and credibility ensure continued relevance of the IN4ACT project to their main concerns;
- *Networking:* expansion and enhancement of cooperation between the School researchers and researchers in other relevant scientific fields across KTU and other research groups and global research networks, through collaboration on projects, joint publications, and participation in quality conferences*;*
- *Increased participation in international research projects*: enhancement of the School's capacity to prepare quality RTD proposals in subjects relevant to Industry 4.0, and ability to assemble relevant requisite expertise for carrying them out in the form of compelling consortia for the attraction of research funds (e.g., Horizon 2020 program, among others);
- *Outreach across society, increased visibility and impact:* Development and fine-tuning of targeted communication and dissemination strategy oriented toward key segments of civil society with consistent emphasis on the challenges – the threats as well as the opportunities, the potentially harmful effects as well as the benefits – of Industry 4.0 for the Lithuanian economy and society.

These streams of activity of the ERA Chair research strategy are focused on the following main strategic objectives, followed by tasks and guidelines for IN4ACT research program (see Table 1 below). It is important to note that one of the main priorities of the IN4ACT project and the ERA Chair research strategy itself, apart from their targeted impact on the development of high-quality academic research, the world of business, and the policy-making community, is broad societal outreach and engagement. The objectives laid out in Table 1 indicate the activities and modalities of engagement with the relevant Industry 4.0 stakeholder community, i.e., academia / research, business, and policy-makers.

Table 1. IN4ACT ERA Chair research strategy: objectives, tasks, and guidelines

Objectives	Tasks	Guidelines
1. Increase the quality and impact of research across the national and international research / scientific community as well as the worlds of business and policy-making (governance)	1.1 Increase the quality and impact of KTU School of Economics and Business research results and publications in international high-ranking journals and periodicals.	1.1.1 Orientation of quality research publications towards Web of Science and SCOPUS publications and magazines published by internationally recognized publishers, paying special attention to FT50 and ABS-rated journals; 1.1.2 Presentations of research results related to Industry 4.0 at high-level international multi-stakeholder conferences;

		1.1.3 Increased engagement with national and, especially, international research projects related to Industry 4.0; 1.1.4 Increased involvement of distinguished professors and younger promising faculty in joint research seeking to increase Industry 4.0 research impact; 1.1.5 Increased participation of School faculty and researchers in national and international project evaluation, editorial boards of scientific journals, and international conference scientific and organizing committees.
	1.2 Increase the relevance and impact of KTU School of Economics and Business Industry 4.0 research results on the business community of Lithuania and internationally.	1.2.1 Increased levels of successful applications for national RTD projects with maximum relevance to the concerns of business and / or regional and national economic development, especially with reference to key issues in Industry 4.0; 1.2.2 Increased levels of advisory representation of faculty and researchers at Lithuania's business associations and other bodies articulating business interests and development visions relevant to Industry 4.0; 1.2.3 Increased numbers of School scientific leaders' expert commentaries and interviews in the press, radio, television, and leading social media; 1.2.4 Increased levels of collaboration between researchers and businesses through executive education programs or seminars on key topics of Industry 4.0; 1.2.5 Increased levels of public presentations of Industry 4.0 scientific project results and other research and monographs with influence on key concerns of the stakeholder community, especially business and policy-makers.
	1.3 Increase the relevance and impact of KTU School of Economics a Business research results on Lithuania's institutions of public administration / governance and enhance influence on broader social and cultural processes.	1.3.1 Foster representation of the School's scientific leaders' participation in Lithuanian institutions developing and implementing economic, innovation, as well as science research strategies, especially in the areas of Industry 4.0 and the implementation of the country's smart specialization strategy; 1.3.2 Raise the School scientific leaders' visibility and authority in public forums or roundtable discussions through expert commentaries, interviews in the national press, radio, television and quality social media on subjects concerning Industry 4.0.
2. *Develop a new generation of researchers of high international caliber with the ability to make significant research contribution to the international scientific / research community but also to the business and policy-making communities of Lithuania*	2.1 Promote internationalization of the research community around the core research thematic areas of Industry 4.0.	2.1.1 Attract to the School international academic scientific leaders into teaching and research engagements on a long-term or time-negotiated basis on Industry 4.0 topics; 2.1.2 Develop strategy for attracting to the School post-doctoral researchers funded by third-party institutions;

		2.1.3 Develop long-term traineeship program for the School's researchers in the leading research centers with focus on the research priorities of Industry 4.0.
	2.2 Strengthen PhD programs of the KTU School of Economics and Business through a transversal methodological and thematic research lens on Industry 4.0.	2.2.1 Monitor and enhance the quality (especially according to leading international standards), and relevance of PhD thesis topics and research methodologies – both in terms of purely scientific merit and influence of the research results on the concerns of stakeholders – especially with reference to Industry 4.0; 2.2.2 Intensify preparation activities with 3rd and 4th year PhD students with focus on enhancing the dissemination and impact of Industry 4.0 research results; 2.2.3 Promote the development of joint cross-disciplinary PhD programs on Industry 4.0 with other KTU faculties.
	2.3 Develop Industry 4.0 research capabilities of young faculty and researchers at PhD and post-doctoral study levels.	2.3.1 Identify, train, and promote prospective young faculty and researchers demonstrating interest in various areas of Industry 4.0; 2.3.2 Integrate prospective young researchers / students to the research activities undertaken by the ERA Chair team.
	2.4 Develop and promote Industry 4.0 research leaders	2.4.1 Establish and support Industry 4.0 clusters on the basis of the most productive Research Groups of the School; 2.4.2. Support and accelerate publications of research scientific leaders in high-level journals and periodicals in research fields relevant to Industry 4.0;
3. *Develop a collaborative research culture – both within the School and internationally – corresponding to the research / scientific requirements of Industry 4.0*	3.1 Support the enhancement of research interdisciplinarity	3.1.1 Develop interdisciplinary science clusters ("seed" projects) that will allow the ERA Chair team to select new Industry 4.0 initiatives in order to increase the impact of stakeholder engagement; 3.1.2. Engage and provide incentives to researchers currently participating in other joint internal KTU initiatives, seeking to enhance interdisciplinarity on key areas of Industry 4.0.
	3.2 Develop key academic partnerships for joint research activities	3.2.1 Develop partnerships with leading business and other schools with international accreditations (i.e., EQUIS, AACSB) involved in research on Industry 4.0 across Europe, North America and Asia (for details see accompanying document D4.1 "Network development strategy"); 3.2.2 Develop partnerships and sustainable working relationships with leading EU and international research centers on public policy, regulation, and standardization bodies, among others (for details see accompanying document D4.1 "Network development strategy").
	3.3 Promote the formation of internal cross-Research	3.3.1 Organize quarterly seminars for identifying research on Industry 4.0 that is

	Group with focus on Industry 4.0.	relevant to existing faculty and researchers of the Research Groups, but also to relevant stakeholders in the business and policy / regulation communities; 3.3.2 Gather, organize, and make available to all Research Group researchers and faculty involved international good practices in research on Industry 4.0.
4. *Develop the School's infrastructure and put into place a system of performance assessment / monitoring along with scientific and related key performance indicators*	4.1 Develop research infrastructure	4.1.1 Promote the usage of existing and newly created laboratories for providing teaching, research and other services to Industry 4.0 stakeholders; 4.1.2 Attract external resources for the development of an socio-economic simulation platform on Industry 4.0.
	4.2 Implement good practices program of research management	4.2.1 Carry out annual strategic planning of scientific indicators and measures, specifically on the subject of Industry 4.0; 4.2.2 Create a researchers' expertise portfolio database that can facilitate cross-disciplinary collaboration on key aspects of Industry 4.0; 4.2.3 Create a School's Science Information System to provide real-time information on researchers' achievements.
5. *Increase participation in international research projects, e.g., Horizon 2020, among others.*	5.1 Enhance the School's capacity to prepare quality RTD proposals in subjects relevant to Industry 4.0, and ability to assemble relevant requisite expertise for carrying them out in the form of competitive consortia for the attraction of research funds.	5.1.1 Organize training sessions for strengthening the capacity of School faculty and especially younger researcher to: 1. Prepare quality RTD proposals on subjects related to Industry 4.0; 2. Sourcing and assembling relevant requisite international expertise for carrying out projects in the form of consortia; 3. Managing the scientific, financial, and official reporting cycles of projects; 4. Developing knowledge and expertise in coordination of international RTD projects. 5.1.2 Deploy internal School research teams for the preparation of proposals for upcoming calls and the identification of suitable research partners, especially in Horizon 2020; 5.1.3 Support and expand the School's Research Groups' participation in international consortia in Horizon 2020 projects.
6. *Outreach across society, increased visibility and targeted impact.*	6.1 Regularly update and calibrate the project's communication and dissemination strategy oriented toward key segments of civil society with consistent emphasis on the challenges – the threats as well as the opportunities, the potentially harmful effects as well as the benefits – of Industry 4.0 for the	6.1.1 Regularly update communication strategy by establishing a "News" section on the IN4ACT project website that details the latest and upcoming activities of the project (e.g., conference presentations, publications, participation in public events and roundtables, press interviews, radio, television , social media etc.), to be updated on a bi-weekly basis; 6.1.2 Develop a pro-active strategy for ERA Chair team and School faculty interventions in public discussions / consultations related

	Lithuanian economy and society.	to aspects of Industry 4.0 and smart specialization; 6.1.3. Develop detailed plan for conference presentations, especially events that involve multi-stakeholder participants; 6.1.4 Organize annual high-visibility conferences at KTU on leading aspects of Industry 4.0 involving high-level speakers from leading international universities and research centers as well as policy development and research organs (e.g., OECD) and also involving agencies of civil-society and relevant NGOs.

About IN4ACT

The objective of the IN4ACT project is to implement structural changes at the School of Economics and Business of Kaunas University of Technology through the opening of an ERA Chair in "Industry 4.0 Management and Economics" research, to increase research excellence, socio-economic impact, international reputation, and attractiveness to international talented researchers and students.

An ERA Chair holder and a team will be recruited to: 1/ Implement an ambitious research agenda on the impact of future manufacturing (Industry 4.0) on management practices and economics; 2/ Drive changes at the KTU School of Economics and Business related with research management and human resources, especially to comply with the ERA priorities; 3/ Improve the School's exploitation, dissemination, and communication capacities; 4/ Grow networks and increase links with stakeholders, especially to increase participation in Horizon 2020.

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