IN4ACT
Research Program 2020-21
Bibliographical Reference Framework

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Rationale and approach

The purpose of this presentation (to be read in conjunction with the IN4ACT Research Strategy document is to outline the zones of leading international literature currents the IN4ACT project engages during the implementation of its research strategy. It can be read as the project's intellectual identity.

Industry 4.0, as a core aspect of what is increasingly referred to as the Fourth Industrial Revolution, is a long-term systemic process that is bound to significantly affect the entire range of business operations regardless of the industrial sector in which firms are located as well as the institutional contexts in which they operate. Its implementation depends fundamentally on putting into place the appropriate 'enabling framework' conditions. These range from technological infrastructures, security/protection of know-how, new business models, novel forms of work organization, new 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 implementation of Industry 4.0 is dependent on the reconfiguration of existing structures of production, civil society and public administration.

In this context, the field of literature engagement of the IN4ACT research strategy extends beyond traditional academic disciplinary boundaries:

- On one hand, this involves the adoption of an interdisciplinary perspective transcending traditional forms of specialization;
- On the other, it demands sustained engagement with stakeholders and social actors beyond the boundaries of academia (i.e., systematic engagement with the world of business, civil society, and institutions of governance, policy and regulation.

Industry 4.0 in historical perspective: defining the 'field'

Focus is on the main aspects of the field the IN4ACT research program by focusing on selected elements of the 4IR. The purpose is to offer an anatomic view of the structural features and drivers of the 4IR.

Research stream

- Brynjolfsson, Erik and Andrew McAfee, (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, New York: W. W. Norton and Company.
- European Commission, (2021). *Industry 5.0: Towards a sustainable, resilient, and human-centric European industry* *https://ec.europa.eu/info/news/industry-50-towards-more-sustainable-resilient-and-human-centric-industry-2021-jan-07_en*
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Industry 4.0 in historical perspective: defining the ‘field’ (Cont’d)

- World Bank Group, (2018). *Trouble in the Making? The Future of Manufacturing-Led Development* https://www.worldbank.org/en/topic/competitiveness/publication/trouble-in-the-making-the-future-of-manufacturing-led-development
- World Economic Forum, (2015). *Deep Shift: Technology Tipping Points and Societal Impact*. Geneva: World Economic Forum. http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf

Method and conceptual framework: ‘anchor’ concepts

The historical setting of… VUCA: Vulnerability, Uncertainty, Complexity, Ambiguity

The Fourth Industrial Revolution 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.

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;
- ***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.

Method, conceptual framework: ‘anchor’ concepts

Technology as biology: *beyond functionalism* – technology as a “tool” – and toward more synthetic evolutionary conceptions. Novel technologies arise by combinations of existing technologies, through a process of *combinatorial evolution*. 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 economy becomes more combinatorial and technology more open, new operating principles are being introduced into the foundations of economies. Order, closedness, and equilibrium as ways of organizing explanations are giving way to open-endedness, indeterminacy, and the emergence of perpetual novelty.

Research stream

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Method, conceptual framework: ‘anchor’ concepts

Globalization as a phase of time-space compression: the “end of geography”? Though it is important to remain focused on the quantitative aspects of globalization (levels of economic integration, velocity of financial transactions, 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’ which 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. Or globalization as “computation”: it does not just denote machinery; it is planetary-scale infrastructure that is changing not only how economies operate and governments govern, but also what governance even is in the first place.

Research stream

- Baldwin, Richard, (2019). *The Globotics Upheaval: Globalization, Robotics, and the Future of Work*. New York: Oxford University Press.
- Bratton, H. Benjamin, (2015). *The Stack: On Software and Sovereignty*. Cambridge, Massachusetts: The MIT Press.
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- Milanovic, Branko, (2018). *Global Inequality: A New Approach for the Age of Globalization*. Cambridge MA: The President and Fellows of Harvard University.
- Pistor, Katharina, (2019). *The Code of Capital. How the Law Creates Wealth and Inequality.* Princeton NJ.: Princeton University Press.
- Wajcman, Judy, (2015). *Pressed for Time. The Acceleration of Time in Digital Capitalism*. Chicago: The University of Chicago Press.
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Method, conceptual framework: ‘anchor’ concepts

The State and innovation: time to dispense with the popular mythology that innovation is a phenomenon set in motion exclusively by entrepreneurs and garage tinkerers under the encouraging eye of the state. Since WW 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. The state, especially in the US, 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, it has also taken an active role in building the physical environments, what have been called “cities of knowledge” within which innovations have been developed. The state is also central on the design and application of the ‘legal code’ of capital.

Research stream

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Method, conceptual framework: ‘anchor’ concepts

The State and innovation: (cont’d)

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- O’Mara, Margaret Pugh, (2005). *Cities of Knowledge. Cold War Science and the Search for the Next Silicon Valley*. Princeton, NJ: Princeton University Press.
- Pistor, Katharina, (2019). *The Code of Capital. How the Law Creates Wealth and Inequality.* Princeton NJ.: Princeton University Press.
- Weiss, Linda, (2014). *America Inc.? Innovation and Enterprise in the National Security State*. Ithaca NY: Cornell University Press.

Program structure and research streams

The program is structured around three levels that leading international research considers as having a decisive influence on the future prospects of Industry 4.0:

- The *micro-level* (the level of the firm, phases and functions of production),
- The *meso-level* (regional economic and innovation ecosystems), and
- The *macro-level* (systems of governance, policy, regulation, and sustainability).

The modules should be considered as conceptual orders, not as compartments, since any of the identified research areas under any specific module is likely to be in interaction with, and influenced by, other areas under different modules.

The modules, with identified key research areas, are as follows:

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

- I. 1: *The decomposition/re-composition of production and the changing value composition of Global Value Chains* (research stream: the changing calculus of opportunities and threats of specific business profiles and value propositions);
- I. 2: *AI: cloud computing, big data, algorithmic models, and the Internet of Everything* (research stream: the functions and uses of predictive analytics, 'smart factories', implications for different business activities such as knowledge management, marketing and human resources);
- I. 3: *The platform economy, its typology and economic specificity* (research stream: types of platforms, e.g., transaction, innovation, integrated and investment platforms, direct and indirect network effects, two-sided networks and the economics of multisided platforms);
- I. 4. *The platform economy business models* (research stream: transitions from product-centricity to platforms, from value chains to ecosystems, from physical assets to digital and intangible assets and innovation capital, from 'labor-heavy' to 'labor-light' etc., structure of business models and their variations, e.g., asset-heavy, mixed, asset-light);
- I. 5 *Industry 4.0. as a matrix of risk and opportunity* (with added emphasis on SMEs) (research stream: technological, organizational, and strategic management challenges, business model (re)design, management challenges concerning security and protection of know-how, risks of loss of control (to larger firms), reduced independence, flexibility and adaptability, performance measurement methodologies).

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

- I. 1: *The decomposition/re-composition of production and the changing value composition of Global Value Chains* (research stream: the changing calculus of opportunities and threats of specific business profiles and value propositions).

Research stream

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

- I. 2: *AI: cloud computing, big data, algorithmic models, and the Internet of Everything (*cont'd)

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

- I. 2: *AI: cloud computing, big data, algorithmic models, and the Internet of Everything (*cont'd)

- TEKES, (2014). "The Industrial Internet: Robotics, Automation and the Future of Manufacturing" https://www.tekes.fi/globalassets/julkaisut/cm_the_industrial_internet_automation_robotics_and_the_future_of_manufacturing_v13.pdf
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Level I: Micro-level: Industry 4.0 in the level of the firm, functions and phases of production:

- I. 3: *The platform economy, its typology and economic specificity* (research stream: types of platforms, e.g., transaction, innovation, integrated and investment platforms, direct and indirect network effects, two-sided networks and the economics of multisided platforms).

Research stream

- Andrews, Dan Chiara Criscuolo and Peter Gal, (2016). *The Global Productivity Slowdown, technology Divergence and Public Policy: A Firm-level Perspective*. OECD Background Paper https://www.oecd.org/global-forum productivity/events/GP_Slowdown_Technology_Divergence_and_Public_Policy_Final_after_conference_26_July.pdf
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- Mazzucato, Mariana, (2016). *The Value of Everything: Making and Taking in the Global Economy.* New York: Hachette Book Group.

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

- I. 3: *The platform economy, its typology and economic specificity* (cont'd)

- McAfee, Andrew and Erik Brynjolfsson, (2017). *Machine, Platform, Crowd: Harnessing Our Digital Future.* New York: W. W. Norton & Company.
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- Van Alstyne, W. Marshall and Michael Schrage, (2016). "The Best Platforms Are More Than Matchmakers", *Harvard Business Review*, August 02 https://hbr.org/2016/08/the-best-platforms-are-more-than-matchmakers
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Level I: Micro-level: Industry 4.0 in the level of the firm, functions and phases of production:

- I. 4. *The platform economy business models* (research stream: transitions from product-centricity to platforms, from value chains to ecosystems, from physical assets to digital and intangible assets and innovation capital, from 'labor-heavy' to 'labor-light' etc., structure of business models and their variations, e.g., asset-heavy, mixed, asset-light).

Research stream

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

- I. 4. *The platform economy business models* (cont'd)

- McAfee, Andrew and Erik Brynjolfsson, (2017). *Machine, Platform, Crowd: Harnessing Our Digital Future.* New York: W. W. Norton & Company.
- Neufeind, Max, Jacqueline O'Reilly, and Florian Ranft (eds.), (2018). *Work in the Digital Age: Challenges of the Fourth Industrial Revolution*. Policy Network https://policynetwork.org/wp-content/uploads/2018/06/Work-in-the-Digital-Age.pdf
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Level II: Meso-level: Industry 4.0 on the level of regions and regional innovation ecosystems:

- II. 1. *Centralization vs. decentralization in Industry 4.0* (research stream: the dynamics of centralization vs. decentralization of economic capacities; management challenges in the context of existing as well as emerging industries and the regional business ecosystems in which they operate);

- II. 2. *The changing economic geography and its implications for regional economic ecosystems* (research stream: the dynamics of concentration of economic capacities few economic centers and the implications for management in regional business ecosystems (e.g., clusters etc.);

- II. 3. *Commoditization and "smart specialization"* (research stream: Industry 4.0 and the reinforcement of dynamics of commoditization of business value propositions and business attractiveness of regional economic ecosystems, critical review of "smart specialization" theory and strategies especially concerning the ability of such strategies to provide a sustainable counterweight to the spatial centralization and commoditization that leading research identifies as key characteristics of Industry 4.0).

- II. 4. *Symbiotic vs. parasitic ecosystems* (research stream: critical perspectives on 'smart specialization' and 'open innovation' [production vs. extraction of value], different systems of financing innovation and sustainable development).

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

- II. 1. *Centralization vs. decentralization in Industry 4.0* (research stream: the dynamics of centralization vs. decentralization of economic capacities; management challenges in the context of existing as well as emerging industries and the regional business ecosystems in which they operate).

Research stream

- Candelon, François, Martin Reeves and Daniel Wu, (2018). "18 of the Top Twenty Tech Companies Are in the Western U.S. and Eastern China. Can Anywhere Else Catch Up?", *Harvard Business Review*, May 03 https://hbr.org/2018/05/18-of-the-top-20-tech-companies-are-in-the-western-u-s-and-eastern-china-can-anywhere-else-catch-up
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- Muro, Mark, Robert Maxim, and Jacob Whiton, (2019). Automation and Artificial Intelligence. How machines are affecting People and Places. Brookings Metropolitan Policy Program. https://www.brookings.edu/wp-content/uploads/2019/01/2019.01_BrookingsMetro_Automation-AI_Report_Muro-Maxim-Whiton-FINAL-version.pdf
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Level II: Meso-level II: Industry 4.0 in the level of regions and regional innovation ecosystems:

- II. 1. *Centralization vs. decentralization in Industry 4.0* (cont'd)

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- Schiller, Dan, (2014). *Digital Depression. Information Technology and Economic Crisis*. Chicago: University of Illinois Press.
- World Bank Group, (2018). *Trouble in the Making? The Future of Manufacturing-Led Development* https://www.worldbank.org/en/topic/competitiveness/publication/trouble-in-the-making-the-future-of-manufacturing-led-development

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

- II. 2. *The changing economic geography and its implications for regional economic ecosystems* (research stream: the dynamics of concentration of economic capacities few economic centers and the implications for management in regional business ecosystems (e.g., clusters etc.).

Research stream

- Austin, Benjamin, Edward Glaeser, and Lawrence Summers, (2018). *Jobs for the Heartland: Place-Based Policies in 21st-Century America* https://www.brookings.edu/wp-content/uploads/2018/03/AustinEtAl_Text.pdf
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Level II: Meso-level II: Industry 4.0 in the level of regions and regional innovation ecosystems:

- II. 2. *The changing economic geography and its implications for regional economic ecosystems* (cont'd)

- Institute for Urban Strategies – The Mori Memorial Foundation, (2017). *Global Power City Index 2017* http://www.mori-m-foundation.or.jp/pdf/GPCI2017_en.pdf
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Level II: Meso-level II: Industry 4.0 in the level of regions and regional innovation ecosystems:

- II. 3. *Commoditization and "smart specialization"* (research stream: Industry 4.0 and the reinforcement of dynamics of commoditization of business value propositions and business attractiveness of regional economic ecosystems, critical review of "smart specialization" theory and strategies especially concerning the ability of such strategies to provide a sustainable counterweight to the spatial centralization and commoditization that leading research identifies as key characteristics of Industry 4.0).

Research stream

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- Foray, Dominique, Paul A. David and Bronwyn Hall, "Smart Specialisation – The Concept" *Knowledge Economists Policy Brief* n° 9, June 2009.
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Level II: Meso-level II: Industry 4.0 in the level of regions and regional innovation ecosystems:

- II. 4. *Symbiotic vs. parasitic ecosystems* (research stream: critical perspectives on 'smart specialization' and 'open innovation' [production vs. extraction of value], different systems of financing innovation and sustainable development).

Research stream

- Block, Fred and Matthew R. Keller (eds.), (2014). "Where Do Innovations Come From? Transformations in the U.S. National Innovation System 1970-2006", *The Information Technology & Innovation Foundation* https://www.itif.org/files/Where_do_innovations_come_from.pdf
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- Jones, A. Gareth, (2017). "The Geographies of Capital in the Twenty-First Century: Inequality, Political Economy and Space", in Heather Boushey, J. Bradford Delong, and Marshall Steinbaum, (2017). *After Piketty. The Agenda for Economics and Inequality.* Cambridge MA: Harvard University Press.
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- Mazzucato, Mariana, (2013). *The Entrepreneurial State: Debunking Private vs. Private Sector Myths*. London: Anthem Press.
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- Summers, H. Lawrence and Ed Balls, (2015). *Report on the Commission for Inclusive Prosperity.* Center for American Progress https://cdn.americanprogress.org/wp-content/uploads/2015/01/IPC-PDF-full.pdf
- Tyson, Laura and Lenny Mendonca, (2015). "Beyond Silicon Valley", *Project Syndicate* https://www.project-syndicate.org/commentary/entrepreneur-job-creation-by-laura-tyson-and-lenny-mendonca-2015-04

***Level III: Macro-level: Industry 4.0 on the level of governance, policy, regulation and sustainability*:**

- III. 1. *Comparative readiness for Industry 4.0: assessment and measurement methodologies* (research stream: emphasis on 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. It is proposed to build on the work of the Industry 4.0 readiness assessment undertaken by the World Economic Forum by applying and elaborating on the Readiness Diagnostic Model Framework (focusing on two main components: structure of production, and drivers of production);

- III. 2. *The future of work: Industry 4.0 skillsets* (research stream: skillset requirements of Industry 4.0, comparative vulnerability of skills and occupational profiles to obsolescence due to Industry 4.0 and automation, the design of work processes and workplaces, skills and training needs at firm level, role of migration and expat communities in assisting Industry 4.0 processes, human resources management);

- III. 3. *Industry 4.0 and social sustainability: the challenges of rising inequality and the threat of social exclusion* (research stream: increasing levels of inequality within firms and society and its management challenges for Industry 4.0. initiatives, social exclusion and segregation by income, education, and class);

- III. 4. *Governance: regulation, innovation and sustainability* (research stream: competition and anti-trust regulation, the emerging challenges of monopoly and monopsony, labor and consumer protection; global governance regarding big data and the platform economy, social accountability and legal compliance (e.g., GDPR), the emerging inter-state tensions regarding the collection, storage and uses of data, the circular economy and sustainability).

Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 1. *Comparative readiness for Industry 4.0: assessment and measurement methodologies* (research stream: emphasis on 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. It is proposed to build on the work of the Industry 4.0 readiness assessment undertaken by the World Economic Forum by applying and elaborating on the Readiness Diagnostic Model Framework (focusing on two main components: structure of production, and drivers of production).

Research stream

- Berins Collier, Ruth, (2015). "The High-Tech Economy, Work, and Democracy 2.0: A Research Agenda", University of California Berkley: Institute for Research on Labor and Employment (IRLE), IRLE Working Paper #114-15 http://irle.berkeley.edu/files/2015/The-High-Tech-Economy-Work-and-Democracy-2.0.pdf
- Deloitte, (2018). *The Fourth Industrial Revolution is here – are you ready?* https://www2.deloitte.com/content/dam/insights/us/articles/4364_Industry4-0_Are-you-ready/4364_Industry4-0_Are-you-ready_Report.pdf
- The Economist Intelligence Unit, (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* http://www.automationreadiness.eiu.com/static/download/PDF.pdf
- European Commission – Digital Transformation Monitor, (2017). *Key lessons from national Industry 4.0 initiatives in Europe* https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Policy%20initiative%20comparison%20v1.pdf
- European Committee of the Regions, (2017). *The Future of Industry in Europe* https://cor.europa.eu/en/documentation/studies/Documents/The%20future%20of%20industry%20in%20Europe/future-of-industry.pdf
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- The European Files, (2017). *Industry 4.0: The New Industrial Revolution for Europe* https://www.europeanfiles.eu/magazine/industry-4-new-industrial-revolution
- European Parliament – Directorate General for Internal Policies, (2016). *Industry 4.0* http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf
- Floridi, Luciano, (2014). *The 4th Revolution: How the Infosphere is Reshaping Human Reality*. Oxford: Oxford University Press.
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Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 1. *Comparative readiness for Industry 4.0: assessment and measurement methodologies* (cont'd)

- IMPULS, (2015). *Indusrtie 4.0 Readiness* https://industrie40.vdma.org/documents/4214230/26342484/Industrie_40_Readiness_Study_1529498007918.pdf/0b5fd521-9ee2-2de0-f377-93bdd01ed1c8
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Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 2. *The future of work: Industry 4.0 skillsets* (research stream: skillset requirements of Industry 4.0, comparative vulnerability of skills and occupational profiles to obsolescence due to Industry 4.0 and automation, the design of work processes and workplaces, skills and training needs at firm level, role of migration and expat communities in assisting Industry 4.0 processes, human resources management).

Research stream

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- III. 2. *The future of work: Industry 4.0 skillsets* (cont'd)

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Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 2. *The future of work: Industry 4.0 skillsets* (cont'd)

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Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 3. *Industry 4.0 and social sustainability: the challenges of rising inequality and the threat of social exclusion* (research stream: increasing levels of inequality within firms and society and its management challenges for Industry 4.0. initiatives, social exclusion and segregation by income, education, and class)

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Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 3. *Industry 4.0 and social sustainability: the challenges of rising inequality and the threat of social exclusion* (cont'd)

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- III. 3. *Industry 4.0 and social sustainability: the challenges of rising inequality and the threat of social exclusion* (cont'd)

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Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 4. *Governance: regulation, innovation and sustainability* (research streams: competition and anti-trust regulation, the emerging challenges of monopoly and monopsony, labor and consumer protection; global governance regarding big data and the platform economy, social accountability and legal compliance (e.g., GDPR), the emerging inter-state tensions regarding the collection, storage and uses of data, the circular economy and sustainability).

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Level III: Macro-level II: Industry 4.0 in the level of governance, policy, regulation and sustainability:

- III. 4. *Governance: regulation, innovation and sustainability* (cont'd)

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Thank You

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