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The Fourth Industrial Revolution – reshaping innovation policies for sustainable and inclusive growth

Note by the secretariat

I. Introduction

1. This note reviews the nature of, potential impact of, and consequences for, innovation policies and institution of the Fourth Industrial Revolution. It is based on the presentations and discussions at the substantive segment on "The Fourth Industrial Revolution – reshaping innovation policies for sustainable and inclusive growth" of the eleventh session of the Team of Specialists on Innovation and Competitiveness Policies, held in Geneva on 1 and 2 November 2018.[1] The event brought together, inter alia, national governments, academic institutions, the business sector and international organisations.

2. Following this introduction, the second section presents the concept of the Fourth Industrial Revolution, or Industry 4.0, and the third section broadly outlines the current debate. The fourth section discusses Industry 4.0 challenges and perils and, and the fifth – its potential benefits and opportunities. The sixth section assesses the role that innovation and industrial policies can play in facilitating the advancement of sustainable growth. The seventh section explores what policies are needed to promote socially inclusive growth in this rapidly environment. The eighth section concludes.

[1] The presentations can be found here.

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II. The Fourth Industrial Revolution: the concept

3. The concept of the Fourth Industrial Revolution or, Industry 4.0, has emerged over the past years to help understand the potentially far-reaching changes to the world economy and society at large that may be observed over the next decades. The term revolution is deliberate, nestling these changes within a larger historical context. Whereas the First and the Second revolutions were characterized by the mechanization of production using water, steam power, and, eventually, electricity, the Third revolution had at its core electronics and information technology, speeding up globalisation, internationalising value chains, and lifting billions of the world's poor out of extreme poverty. The core of the fourth revolution is the fusion of technologies that are "blurring the lines among the physical, digital and biological spheres".[2]

4. The driving force of the Fourth Industrial Revolution is innovation or experimenting with ideas that use existing and new physical, digital and biological technologies to transform how we produce, consume, and interact and, ultimately, how we meet the Sustainable Development Goals. The proponents of Industry 4.0 expect the development and adoption of new technologies to accelerate significantly in the coming decades due, among other factors, to the cumulative nature of technological change, the exponential nature of technologies (e.g. microchips), the reduction of costs, and the emergence of digital platforms.[3]

5. Those technologies include robotics and the Internet of Things but also Artificial Intelligence which has the potential to transform production processes and the way of doing business; 3D printing that can make production faster and cheaper; nanotechnology – the manufacture and use of materials at an infinitesimal scale and; biotechnology which allows genetic modification for human medicine as well as agriculture, among others.[4]

6. The main feature of Industry 4.0 is the speed of change, and its impact on systems. It is evolving rapidly, potentially affecting almost every economic sector everywhere, and transforming, according to the World Economic Forum, entire systems of production, management and governance.[5]

III. Industry 4.0 – the current debate

7. The Fourth Industrial Revolution will offer new ways to create value and consume, transform how we deliver and access public services, and enable new ways to interact and govern. Almost every aspect of life could be affected: employment, business models, industrial structures, social interactions, systems of governance.

8. This has sparked a vibrant debate not only on the potentially enormous economic benefits, but also on the challenges for sustainable development that societies, governments, and businesses will need to address – such as inclusion, inequality, competitiveness, and job losses.

[2] The World Economic Forum, "The Fourth Industrial Revolution: what it means, how to respond", 2016.

[3] UNCTAD, "Technology and Innovation Report 2018 – Harnessing Frontier Technologies for Sustainable Development".

[4] Ibid.

[5] The World Economic Forum, "The Fourth Industrial Revolution: what it means, how to respond", 2016.

9. The optimists contend that technological advancement brings growth, higher productivity, higher output per person, and increased quality of life. The transition costs in labour market will be short lived, especially if mechanisms are in place to develop the right skills. The optimists therefore recommend accelerating the transition to robotisation worldwide. Developing countries should thus build digital infrastructures and skills to grow higher value-added activities within the national economy.[6]

10. Industry 4.0 pessimists, on the contrary, stress how digital technologies and globalisation may exacerbate inequality in the labour market, imposing economic, social, health and political costs on vulnerable segments of society. They contend that the cost of automation is falling rapidly, leaving behind countries that do not own the technology and the segments of society without the appropriate skills. The result will be underemployment, lower relative wages for people with low or increasingly obsolete skills, and increased income concentration at the top. Decreased scope for offshoring of and increasing re-shoring of production will accelerate the trend of premature de-industrialisation among developing and transitioning economies, decreasing the scope for long-term sustainable development in those countries.

11. Research has come to different estimates on the effects of automation on employment. Frey and Osborne (2013)[7] estimated that 47% of US workers will be at risk in the next 20 years. The World Bank[8] estimated that 57% of the workers in OECD countries will be affected; but for Arntz et al. (2016),[9] the jobs at risk in the OECD are only 9%, as within an occupation, many workers specialise in tasks that cannot be automated easily, and as new employment and investment opportunities emerge.

12. Acemoglu and Restrepo (2017)[10] argue that in an 'aggressive' scenario in which the world stock of industrial robots would quadruple by 2025, the employment to population ratio will be lower by a 0.94-1.76 percentage points and wage growth will lower by 1.3-2.6% in the period 2015 – 2025.

13. Ultimately the costs of automation and the change of wages in response to the threat would determine whether firms will replace workers with robots. Productivity improvements may create new jobs in the firm, or other occupations might also be able to expand.

IV. Industry 4.0: challenges and perils

14. The potential perils of the Fourth Industrial Revolution are centred around two sets of related issues: the level and quality of employment, skills and education, and higher inequalities in the distribution of income and wealth within and across countries.

15. Indeed, one of the main perils of Industry 4.0 is the potential polarization of the labour market which could lead to economic insecurity and precarious employment. In the United States more than 40% of households cannot meet an unexpected outlay of $ 400 without borrowing or selling an asset. In Germany unemployment has halved in the past years from 11 to 5% and real wages have risen, however we also witness the rise of a new

[6] Mayer J., 2018 “Robots and Industrialization: what policies for inclusive growth?”.

[7] Frey, C. B. and Osborne M. A. (2013) “The Future of Employment: How Susceptible are Jobs to Computerisation?” Mimeo. Oxford Martin School.

[8] World Bank (2016) *World Development Report 2016: Digital Dividends.*

[9] Arntz, M, Gregory T., and Zierahn U. (2016) “The Risk of Automation for Jobs in OECD Countries”, OECD Social, Employment and Migration Working Papers, No. 189, OECD

[10] Acemoglu D., Restrepo P., “Robots and jobs: evidence from the US” 10 April 2017.

lower class and the precariat:[11] one million people are currently employed in temporary work without protection against dismissal, over 3 million have only temporary work contracts with mild protections.[12]

16. The Fourth Industrial Revolution may exacerbate existing trends towards rising unemployment and income and wealth inequality, both within and across countries, in part due to the growth in precarious temporary or contract-based employment. Rising inequality will likely depress aggregate demand, which would lessen the incentives and increase the risks for businesses to invest and expand employment. The latter may be a cause of declining productivity growth.

17. It is estimated that wealth at the "very top fractiles of the global wealth distribution has been rising on average at about 6 to 7% in real terms over the 1987 – 2013 period – three times as fast as the average global wealth".[13] When large parts of the population sense that the system is rigged in favour of wealthy, well-connected, and highly-skilled elites, trust in business and in political institutions falls, fuelling the rise of populist, protectionist, and anti-establishment movements. To what extent these developments have been caused by innovation, as opposed to globalisation, or labour market de-regulation, is not always clear.

18. Innovation has always resulted in some jobs becoming obsolete, as old products, processes and industries were being replaced by new ones. Industry 4.0, will certainly have this effect but it will also open new challenges related to production and structural transformation. Technologies like automation, robotics, additive manufacturing, coupled with changes to the structure of supply and demand and transactions costs, could turn some previously labour-intensive activities into capital-intensive ones – reducing or removing the incentive to outsource labour-intensive activities to low-wage labour markets in developing and transition economies. Textile and automotive companies are increasingly bringing previously outsourced production back from emerging economies – reducing the many valuable opportunities that have propelled hundreds of millions of people in the developing world from destitution into the middle class over the past decades.

19. Historically, this kind of structural transformation has seen the rise of new jobs and sectors, often in services, rapidly replacing and slowing demand for labour in manufacturing and agriculture. However, there are also large uncertainties, especially in the short and medium term about how this will happen, how long it will take, and how the benefits will be distributed among countries, regions, and segments of the population.

20. Knowledge, governance, and infrastructure gaps between developing and developed economies continue to widen and will affect countries in transition to a significant extent. In this context, it is paramount to find other ways of sustaining demand and employment, raising public revenues and distributing income and wealth more equally.

V. Industry 4.0: the benefits and opportunities

21. The benefits that the Fourth Industrial Revolution can bring at the global level and to countries ready to harness its opportunities are large. New business ideas and technologies

[11] The precariat is a social class formed by people in a condition of existence without predictability or security in their employment, affecting their material or psychological welfare.

[12] Brittner J., 2018 "What's wrong with Germany's social democrats".

[13] Piketty T. and Saez E. , 2014 "Inequality in the long run", Science, American Association for the Advancement of Science, 344 (6186), pp.838-843.

promise not only radical gains in efficiency and productivity, but completely new economic opportunities.

22. The costs of transportation and communication will continue to decrease, or even, in some cases, disappear entirely, especially as manufacturing firms develop their capabilities to provide services and solutions which supplement their traditional products offering, so reducing the need for physical shipping and logistics.[14] This is especially the case for trading services across borders, tapping into the human resource pool of economies in transition. These economies could often leapfrog to the latest technologies and standards, bypassing intermediate stages. Mobile telephony and banking, for instance, have supplanted the need to invest in cable networks and bank branches in many developing countries.

23. By one estimate, the global Internet of Things market alone can be worth $14.4 trillion by 2022, which could be a primary economic driver to increase GDP in the decade ahead. In parallel, through improvements to operational efficiency and productivity, 84% of Internet of Things deployments are also advancing the Sustainable Development Goals.[15]

24. Artificial Intelligence has made it possible to automate a growing range of functions in established processes, value chains and operations; develop new business models, products, services and systems; transform value chains and sectors for new development tracks; and radically improve governance and public services. A considerable increase of Artificial Intelligence applications in business, the public sector and society has not only the potential to improve the quality and efficiency in various operations, but also to increase growth and improve welfare.

25. Innovation and technological upgrading are essential for sustainable development, including the main means to achieve the targets of Sustainable Development Goal 8 on decent work and economic growth, particularly because they boost economic productivity, entrepreneurship and resource efficiency. Connectivity and digitization have also created new opportunities– they have empowered citizens; transformed work, created new business models and accelerated innovation. This will also benefit the most vulnerable segments of society. Vodafone Instant Schools Initiative, for instance, has been successfully using technology as an enabler to leapfrog development and fight inequality for the achievement of the Sustainable Development Goals 4, 5 and 8. For example the Initiative Instant Schools for Africa developed with learning Equality, provide millions of young people in the Democratic Republic of Congo, Ghana, Lesotho, Mozambique and Tanzania with free access to online learning materials and education. More than 215 000 young people are able to learn anywhere through their tablet or smart phone, easily follow video lessons, revise through questions and quizzes and evaluate their progress.[16]

26. Industry 4.0 could also open new opportunities for investment. Risk finance, such as venture capital, will be crucial to catalyse broad experimentation with new technologies and business ideas and to enable the work of accelerated technical change champions.

27. The right rules of the game and effective mechanisms for diffusion of good ideas among and within countries and regions will be essential. The Intellectual Property regime for the emerging technologies, especially robots, is still to be defined, tested, and agreed,

[14] UNIDO, “Industry 4.0, Opportunities and Challenges of the New Industrial Revolution for Developing Countries and Economies in Transition” 2016.

[15] World Economic Forum says at the eleventh session of the UNECE Team of Specialists on Innovation and Competitiveness Policies, Geneva 1-2 November 2018.

[16] Vodafone statement at the eleventh session of the UNECE Team of Specialists on Innovation and Competitiveness policies, Geneva 1 November 2018.

and new regulatory approaches are needed to address properly issues such as privacy, discrimination, vehicle safety, and Artificial Intelligence.[17] Ensuring effective technology transfer mechanisms will be crucial to the achievement of the Sustainable Development Goals. Much can be achieved through technology demonstration projects and capacity building centres on specific areas of technological change.

28. Finally, the Fourth Industrial Revolution has also the potential to increase energy and resource efficiency and hence protect the environment and reduce carbon emissions by developing and scaling up resource and energy efficient technologies. It can be an enabler for the transition to a circular economy, and to more sustainable consumption and production patterns, by closing value creation networks, reusing resources and retrofitting machines. It facilitates recycling through design and process organization and management and reduces the physical transport logistics processes.

VI. Innovation and industrial policies for sustainable growth

29. Industry 4.0, as discussed above, can enable more sustainable production patterns, and industrial and innovation policies have a key role to play in supporting sustainable growth.

30. The manufacturing cycle of a product – extraction, production, consumption and disposal - can create severe negative environmental externalities, such as pollution. In fact, higher consumption of products worldwide has accelerated the depletion of non – renewable resources and put pressure on renewable ones. This translates, for example, into water scarcity, a non-manageable waste load, particularly of plastic and toxic materials, and an increase in carbon emissions. A paradigm shift in consumption and production patterns is needed, to keep growth within planetary boundaries.

31. The Circular Economy may be broadly defined as a system where the value of products, materials and resources is maintained in the economy for as long as possible. What is considered waste in the traditional linear economy is increasingly turned into an asset or resource in the Circular Economy. It is restorative and regenerative by design, enhancing and preserving natural capital, optimising resource yields and minimising system risks by managing stocks and renewable flows.[18] In the Circular Economy, the goal is to decouple global economic development from the consumption of finite resources.

32. Circular economy business models often make good use of digital technologies such as the Internet of Things, big data and blockchain to help companies to track resources and monitor utilization and waste capacity. They are also based on physical technologies such as 3D printing robotics, energy storage and harvesting, and nanotechnology that help companies reduce production cost, material use, carbon emissions, and overall the environmental impact. They can also use biological technologies such as bio-energy and bio-based materials that help companies move away from fossil-based energy sources. New technologies, processes, services and business models are re-shaping product life cycles from design through production and usage on to disposal and recycling.

33. There are positive signs that global markets are shifting towards cleaner growth. For example, 85% of the world's projected $10.2 trillion investment in power generation over the next two decades is expected to be in zero-carbon sources.[19] Electric vehicles are

[17] The Economist, "There are no killer robots yet—but regulators must respond to AI in 2019" 17 December 2107.

[18] Definition by Ellen MacArthur Foundation.

[19] The United Kingdom "the Clean Growth Strategy, leading the way to a low carbon future", 2017.

projected to make up over 50% of global car sales by 2040, from around 1% today. The global markets for green bonds – a bond specifically earmarked to be used for *climate* and environmental projects - has been growing rapidly from $7.2 billion in 2012 to over $80 billion in 2016.[20]

34. To enable the transition towards a circular economy using the opportunities of the Fourth Industrial Revolution, Governments should develop policies that incentivise new business models and the right actions from business; collaborate across departments to establish coordinated and multi-dimensional policies; assess how local communities will be impacted economically, environmentally and socially; and update policies over time to take into account new developments and opportunities as well as unforeseen outcomes.

35. Green industrial and innovation policies and regulations are central to the transition to a circular economy and the structural changes required. The manufacturing industry needs to go beyond silos and consider the interrelationship between manufacturing and other development factors. A new paradigm of industrial policy making is needed that works across sectors and disciplines and integrate all level of governments and stakeholders.[21]

36. Experience from the UK industrial policy strategy and the UK clean growth strategy to lower carbon emissions underlines the need to encourage innovation, develop high quality jobs and support businesses to thrive and grow. The UK Industrial Strategy addresses grand challenges – society-changing opportunities and industries for the future, as well as building long-term partnerships with sector-specific deals between Government and the private sector. The first Clean Growth Grand Challenge mission was announced by the UK Prime Minister in May 2018 with the aim of using new technologies to halve the energy use of new buildings by 2030.

37. The UK industrial strategy aims at boosting productivity by backing business to create good jobs and increase the earning power of people throughout the UK with investment in skills, industries and infrastructure. Some of the challenges include addressing underinvestment in research and development and improving the ability to commercialize new ideas.

38. Industries need the right incentives, rules, and price signals to shift to clean growth, through leading the world in the development, manufacture and use of low carbon technologies, systems and services that cost less than high carbon alternatives.

39. As another example, Italy is embracing a logic of technological and sectoral neutrality, preferring fiscal measures and horizontal actions to case-by-case "calls for tender". The four pillars of the Italian response to Industry 4.0 are: innovative investments, skills, enabling infrastructures and public support instruments, including the creation of digital innovation hubs and Industry 4.0 competence centres.

40. One of the main challenges in Italy remains the slow rate of diffusion of Industry 4.0 technologies among SMEs, and poor uptake of policy instruments, such as fiscal incentives. A survey done by the Ministry of Economic Development and MET, a consultancy, showed that only 20 percent of small firms have investment planned on Industry 4.0. The Italian industrial sector is indeed based largely on SMEs where increasing productivity is highly needed. One standing policy priority is the upgrading of technological skills in the labour force, as well as more vocational training. The government guidelines also include steering

[20] Ibid.

[21] UNIDO 2016, "Practitioner's guide to strategic green industrial policy".

existing instruments to promote technological leap and productivity and coordination with stakeholders without acting as a controller or decision-maker.

VII. Innovation policies for inclusive growth

41. Not every country and segment of society will benefit from the Fourth Industrial Revolution in the same way. Governments have a key role to play in ensuring that innovation-driven growth will be inclusive and sustainable. The main policy areas to be targeted are increased investments in education and infrastructure, and appropriate competition and regulatory policies.

42. Not all countries have been equally successful at generating poverty-reducing, sustainable growth, and income inequality has risen within some of the fast-growing countries. Challenges for transition economies might include a widening of technology and knowledge gaps and its implication on skills and rising inequalities.

43. In many European countries, in addition to endemic, often long-term un- or underemployment, the share of involuntary temporary, free-lance or part-time jobs has increased since the financial crisis. There is evidence of people being at increased risk of poverty. This is a challenge for the achievement of the Sustainable Development Goals.

44. Education and infrastructure determine the capabilities of economies and societies to innovate, and to do it inclusively. Each society has developed a distinct knowledge base which determines the capabilities to innovate and diversify. The more diverse, sophisticated and complex the knowledge base, the more feasible the opportunities for the economy. The knowledge base determines the feasible path of economic development, and the products, clusters and industries the country can develop. The knowledge base of a society also determines the capabilities to innovate, develop new industries and create jobs.

45. Education and training policies need to develop capabilities to innovate. They enlarge and enrich the knowledge base in society and increase diversity and complexity. They build and nurture the skills and competencies needed in the economy. This requires a comprehensive learning strategy which includes education and learning in schools, families, communities and workplace. Governments must align these efforts with industrial, innovation and trade policies and the needs of the economy more broadly to translate Industry 4.0 opportunities into innovation, diversification and sustainable employment.

46. For innovation to provide benefits in an inclusive way, policymakers need to adopt clear and feasible national innovation strategies with objectives to enhance digital infrastructure, strengthen the societal knowledge base, and design proper rules and support mechanisms in areas such as taxation, competition and data privacy. Competition and regulatory policies should help ensure that the benefits of innovation are broadly shared throughout society.

47. A reactive, flexible, and comprehensive innovation policy is needed to reduce dependence on technology transfer and increase FDI, to promote technology diffusion and adoption. This requires a close look at the Intellectual Property regime, policies towards inward FDI, increased spending on Research and Development and demand–side led innovation through industrial policy.

48. As the proportion of adult population on formerly middle-class income falls and the proportion in the precariat rises, government must find other ways of sustaining demand and raising public revenues, tackling the variables on level of income and level of employment and triggering employment opportunities through public management.

49. Governments will ultimately have to change the way they regulate, fostering close collaboration with businesses and civil society, and better understanding why and what they regulate. Governments will have thus to shift to "agile governance", defined by the World Economic Forum[22] as creating a legislative and regulatory environment that fosters resilience to the uncertainty of social, economic and technological shifts, creating the maximum space for future innovation.

VIII. Conclusions

50. The Fourth Industrial Revolution will affect entire systems of production, management and governance. The response to it must be integrated, flexible and comprehensive, involving a wide range of public and private stakeholders, structured across different policy areas, carefully coordinated among countries and regions.

51. To address the impact of Industry 4.0 technologies, governments will have to adopt agile governance, thus changing the way they develop and implement regulations and create new instruments to harness the opportunities offered by the new technologies and tackle the challenges. This requires from the regulators higher efficiency and effectiveness of consultation, improved transparency and more flexibility.[23]

[22] World Economic Forum, "How can policy keep pace with the Fourth Industrial Revolution?", February 2018.

[23] Ibid.