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Contribution of Turkey

to the CSTD 2018-19 priority theme on ‘The role of science, technology and innovation in building resilient communities, including through the contribution of citizen science’

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Contribution of Turkey to CSTD 2018-2019 Inter-sessional Panel

Theme 1: The impact of rapid technological change on sustainable development

There is no doubt that the digital transformation is affecting the rate of innovation in a positive way. The digital transformation enables greater access to knowledge, which spurs accelerated knowledge production and interaction that has significant spill-overs across society.¹ The spill-overs reach even to the market penetration and hype cycle of various technologies. In addition, digital transformation in the industry and other societal systems can be observed to have an impact on increasing the pace of the learning curve. The path for breakthrough technologies can be better supported with digital access. More efficient production processes can more quickly lower the costs of unit production. Conversely, the late adoption of digital innovations² can hinder the pace of innovation. Limited access to knowledge and interaction puts forth a higher probability that learning curves will be less steep and productivity gains will be lower.

For this reason, in this crucial time of human civilisation, it is even more important to manage R&D and innovation so that relevant approaches can keep pace with the increased rate of innovation. The management approach should be more agile and flexible to respond and adapt to the arising needs and opportunities in a digitally transforming world. According to the transformation maps of the World Economic Forum,³ the world is yet to fully experience the productivity gains from the ongoing fourth industrial revolution. The coordinated action of the R&D and innovation system is needed to enable the realisation of the fourth industrial revolution. In addition, machine learning is seen to be central to a high-growth, high-opportunity economy from estimating the state of charge for electric vehicles⁴ to 3-D printing processes.⁵ Similarly, the use of big data is an essential tool for better understanding societal processes and opportunities for optimisation. Blockchain is another facilitator of the pace of innovation since it redefines a process of direct economic transactions that has ramifications for supply chains as well as distributed energy systems. For example, prosumers can establish a “digital wallet” for exchanges of energy between other prosumers, including from renewable and waste energy.

We should all recognise the diffused impact of digital transformation on the rate of innovation and seek to improve the management of R&D and innovation to correspond with this pace. In Turkey, the Scientific and Technological Research Council of Turkey (TÜBİTAK) has coordinated the “Smart Manufacturing Systems Technology Roadmap.” The roadmap is based on the technology groups of digitalization, interaction within the scope of smart manufacturing systems and factories of the future with 8 critical technologies and 29 critical products. A comprehensive participatory process with wide-ranging participation included the definition of technology groups, technology based strategic targets, critical technologies, the determination of R&D projects and prioritised sectoral

¹ Machine learning will be the engine of global growth, The Financial Times Limited 2018, <<https://www.ft.com/content/133dc9c8-90ac-11e8-9609-3d3b945e78cf>> (16.11.2018).

² Jahanmira, S., Cavadas, J., (2018) Factors affecting late adoption of digital innovations, Journal of Business Research Vol. 88, pp. 337-343 <<https://www.sciencedirect.com/science/article/pii/S0148296318300584>> (16.11.2018).

³ World Economic Forum <<https://toplink.weforum.org/knowledge/explore>> (16.11.2018).

⁴ Zahid, T., et al. (2018) State of charge estimation for electric vehicle power battery using advanced machine learning algorithm under diversified drive cycles, Energy Volume 162, pp. 871-882 <<https://www.sciencedirect.com/science/article/pii/S0360544218316037>> (16.11.2018).

⁵ Zohdi, T., (2018) Dynamic thermomechanical modeling and simulation of the design of rapid free-form 3D printing processes with evolutionary machine learning, Computer Methods in Applied Mechanics and Engineering Vol.331, pp. 343-362 <<https://www.sciencedirect.com/science/article/pii/S004578251730748X>> (16.11.2018).

applications. In this multi-layered roadmap approach, it was possible to associate a critical technology to specific R&D projects and sector applications, which has been an effective way to provide guidance to the new industrial revolution in Turkey.

Theme 2: The role of science, technology and innovation in building resilient communities, including through the contribution of citizen science

A way to build resilient communities can be through enhancing society's readiness for disruptive technological changes. It is known that **demand from "lead users"** are crucial for defining societies' readiness for disruption.⁶ Lead-users are defined as "customers that face needs ahead of the general market and who benefit significantly from finding solutions to those needs."⁷ When demand from lead users is strong, the pull towards disruptive innovation is higher and vice versa. For example in Turkey, the definition of R&D projects and sectoral applications in the Smart Manufacturing Technology Roadmap has facilitated the process of determining potential areas of "lead users" for the pilot applications of the critical technologies. Based on this experience, policies that integrate considerations from both the supply and demand sides will provide a better chance of success for enhancing societies' readiness for disruptive innovation.

On the other hand, complementary policies will still be needed to mitigate the effects of structural changes in the economy, such as the **structure of employment and change of the skills base for human resources**. In these aspects of inequality that is induced by disruptive innovation, agile policies and governance are needed to increase the **mobility of the human resources based on training and opportunities for new skill acquisition**. But we also recognise that the digital age provides increased opportunities to develop new skills to counteract job displacement. For this reason, in contrast to the previous industrial revolutions, it may be possible to re-balance the match for skills in the economy in a shorter period of time. In the context of "proactive talent management strategies"⁸ that are necessary to counteract job displacement due to disruptive innovation, we as Turkey recognise the importance of new scholarship and fellowship programs. As examples, new Industrial Doctoral Scholarship Program and recently launched International Fellowship for Outstanding Researchers seek to raise and attract qualified human resources that address industrial needs and research frontiers. Based on trending industrial challenges and research frontiers, both of these scholarship and fellowship programs can enable **a better match in the skills base to innovation opportunities**.

- **Industrial Doctoral Scholarship Program:** The provision of an inclusive capacity to the private sector to improve their technological competences and level of technological diversification further depends on the access of the private sector to high-quality human resources. With this newly designed scholarship program that is launched in July 2018, higher education institutes, certified research laboratories and private sector firms can make a joint

⁶ Roy, R., (2018) Role of relevant lead users of mainstream product in the emergence of disruptive innovation, *Technological Forecasting and Social Change* Vol. 129, pp. 314-322

<<https://www.sciencedirect.com/science/article/pii/S0040162517314646>> (16.11.2018).

⁷ Von Hippel, E. (1986), Lead users: A source of novel product concepts, *Management Science*, 32 (7), pp. 791-805.

⁸ World Economic Forum, Disruption to Jobs and Skills <

<https://toplank.weforum.org/knowledge/insight/a1Gb0000001RihBEAW/explore/dimension/a1Gb00000027vYXEAY/suimary>> (16.11.2018).

application with involvement from private sector R&D and product design centres as well as start-up firms in technoparks. According to the application, the program will provide four-year scholarships to students for PhD studies and support for employment after graduation. In total, 500 industrial doctoral program students will be supported.

- **International Fellowship for Outstanding Researchers:** The new fellowship targets qualified researchers with leading scientific and/or technological achievements and international working experience to come to Turkey to conduct their research in leading academic, industrial or public institutions. It is expected that the research fellows will contribute to projects in research areas that are of strategic value to our country. Both young and experienced researchers are expected to satisfy high expectations for taking place in the list of Highly Cited Researchers of Clarivate Analytics or conducting research in one of the top 100 universities according to the QS (Quacquarelli Symonds) World University Rankings or one of the top 2500 companies with the highest R&D expenditures according to the Industrial R&D Investment Scoreboard.

This support program which has been implemented by TÜBİTAK, has a feature to be novel and frontier in the world with respect to the financial supports provided to the researchers coming to Turkey. In addition to the monthly living allowance provided to the researcher, a research support will also be granted to his/her RDI activities in Turkey. Subsequent to the start of the support period, an additional “starting grant package” will be provided to be used for the costs of required equipment, maintenance of the devices, etc. Moreover, fellowship costs will be covered up to 5 doctorate students who will be within the research team of the outstanding researcher coming to Turkey. Family allowance will be provided to the researcher for his/her spouse and children, as well as health insurance for the whole family members.