UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Industry 4.0 – the opportunities behind the challenge

Comments

Comments and suggestions on issues raised in this report are welcome and may be addressed to Olga Memedovic at o.memedovic@unido.org.

The 17th session of the United Nations Industrial Development Organization (UNIDO) General Conference, *Partnering for impact – achieving the Sustainable Development Goals*, was held in Vienna, Austria from 27 November to 1 December 2017. During the event, representatives from the private sector, governments and academia met for a panel discussion organized by UNIDO's Department of Trade, Investment and Innovation entitled *Industry 4.0: the opportunities behind the challenge*. The discussion focused on how recent disruptive technological innovations in production and leaps forward in industrial production, referred to as Industry 4.0 or the Fourth Industrial Revolution, are affecting our lives today and will shape societies in the future.

The event was divided into two panel sessions. The first panel discussed the opportunities that Industry 4.0 will bring to the economy and society and the role of education in seizing these opportunities. The second panel focused on the roles that governments and the international community can play in supporting developing countries to address the challenges posed by Industry 4.0, particularly in regard to achieving the Sustainable Development Goals (SDGs).

Interaction with the audience was enabled through a smartphone application called sli.do. Participants were able to pose questions to the speakers. In particular, they voiced concerns about the impact that technological advances will have on jobs, especially for developing and least developed countries (LDCs).

WHAT:
Panel discussion at 17th UNIDO General Conference

WHEN:
29 November 2017

WHERE:
Vienna International Centre, Austria

EXECUTIVE SUMMARY

We are on the cusp of the Fourth Industrial Revolution, also called Industry 4.0. Major technological advancements are revolutionizing industrial production, where automation of manufacturing processes is upgraded with smart autonomous systems capable of self-cognition, self-optimization, and self-customization. Industry 4.0 will affect all sectors and disciplines, and will have a huge impact on developing countries in particular, where a concentration of low-paid jobs is likely. High-wage jobs will require increased digital skills, and weak education systems in developing countries are often failing to provide basic skills in literacy and numeracy.

Industry 4.0 is likely to be accompanied by increased demand for science, technology, engineering and math (STEM) qualifications in manufacturing. In the STEM environment, the skills bottleneck is likely to be felt most in developing countries, because of significant information asymmetry in new technologies, with a huge difference in the level of access to knowledge between developed and developing countries, between rich and poor, and between large and small firms. Access to learning new skills in technology and science and building innovation ecosystems for technological learning and innovation will be crucial to enable developing countries to play an inclusive role in the global market.

UNIDO's role is pivotal in building awareness of Industry 4.0's potential to bring about inclusive and sustainable industrial development (ISID) and achieve the Sustainable Development Goals (SDGs). It can do this by promoting the development of new norms and standards, carrying out research to support policy advice, building knowledge sharing platforms and developing the appropriate technical cooperation for UNIDO Member States. Innovation, knowledge sharing and exchange and the development of strategic partnerships are vital to realizing the potential of Industry 4.0 technologies for achieving the SDGs.

The key conclusions from the panel discussions were:

- Developing countries must keep up with technological changes to ensure that they are not left behind by Industry 4.0.
- Applying Industry 4.0 technologies can be a gradual process and some solutions do not have to be expensive.
- Good ICT infrastructure is needed to help SMEs move into the digital economy.
- Countries and companies will need a digital strategy, and a strategic vision for a fully integrated multi-stakeholder policy approach.
- Education and technical qualifications should play an integral role in digital strategy and business friendly environment.
- Continuous learning and on-the-job training are necessary to develop the new skills required for Industry 4.0.
- UNIDO has a key role to play in building awareness of the potentials of new technologies for inclusive and sustainable industrial and economic development through establishing platforms for dialogue, knowledge and experience sharing.

“Industry 4.0, or the Fourth Industrial Revolution, is bringing about a paradigm shift that will profoundly change the way we work, live and interact and will affect industrialized as well as industrializing economies alike.” LI YONG, Director General of UNIDO

1. INTRODUCTION

The major technological advancements of the Fourth Industrial Revolution, or Industry 4.0, are revolutionizing industrial production. The First Industrial Revolution was based on mechanization and steam engines; the second on the use of electricity energy and mass production; and the third on electronics and information technologies, resulting in a high level of automation in manufacturing. Industry 4.0 takes automation of manufacturing processes to a higher level with smart autonomous systems capable of self-cognition, self-optimization, and self-customization.

Industry 4.0 includes concepts, tools and applications that complement a smart embedded system of machines able to communicate with each other and people and perform autonomous tasks in industrial production processes. The main tools include cyber-physical systems (CPSs), the Internet of Things (IoT), big data and cloud computing, autonomous robots, simulation and visualization models, and additive manufacturing. Automation and robotics are perceived as key components – the arms and legs – of Industry 4.0; cameras and other sensors are perceived as the senses; data and connectivity are compared to the nervous system; and artificial intelligence (AI) is the brain. AI enhances industrial processes by enabling the synergetic collaboration between humans and robots in smart factories for mass customization.

Industry 4.0 will affect all sectors and disciplines, bringing about a structural transformation in the global economy and leading to a new division of labour, which will have a huge impact on developing countries. A new wave of outsourcing and in-shoring will be triggered, with new technologies, such as additive manufacturing using innovations such as 3D printing, rendering some outsourcing unnecessary. In-shoring could become a new trend in industrialized countries, depriving developing countries of job opportunities. Many predict that Industry 4.0 will cause a polarisation of the labour force, with an increasing share of employment in high- and low-wage jobs and a decreasing share of employment in middle-wage jobs. A concentration of low-paid jobs in developing countries is likely, given that high-wage jobs will require increased digital skills and that weak education systems in developing

countries often fail to provide basic skills in literacy and numeracy. There is likely to be an increased demand for STEM qualifications for manufacturing jobs. The skills bottleneck is likely to be felt most in developing countries, especially in LDCs, because of a significant information asymmetry in new technologies, and a huge difference in the level of access to knowledge between developed, developing and LDCs, between rich and poor, and between large and small firms. These developments will therefore have an impact on inequalities within and between countries.

Production systems will become more dynamic, flexible, efficient, environmentally sustainable and inclusive through extensive customization and personalization. There will be a decrease in material resources and energy consumption, and new product designs will be introduced that optimize the use of new advanced materials and nanomaterials with beneficial properties, shorten transport routes, and cut transaction costs. Industry 4.0 will also contribute to realizing the circular economy, in which end-of-life products are reused and recycled, and to facilitating the reaping of benefits and opportunities from this.

This transformation will also bring with it a change in the nature of jobs, requiring not only increased technical competencies but also interpersonal skills, and will feature remote, flexible and on-demand work.

Challenges of Industry 4.0

- Infrastructure gaps
- Outdated international rules and regulations that do not take into consideration Industry 4.0
- Standards and interoperability
- Data ownership and security
- Incentives and obstacles that may shape the development and diffusion of these new technologies (intellectual property protection and others)
- Reliability and stability of CPSs
- Transparency, privacy, ethics and security
- Inequality and exclusion
- Changes in the very nature of innovation processes and the implication for competition and barriers to entry

Opportunities of Industry 4.0

- Economic gains, such as increased revenues because of lower transaction and transportation costs
- More reliable and consistent productivity and output and better quality products
- Shift to mass customization with an increased role for SMEs
- Enabling innovation across many applications, with much larger economic impact on growth
- Energy-efficient and environmentally sustainable production and systems
- Effective use of human and material resources
- Increased food security and safety
- Improvements in the health and safety of workers
- Changes in education and training systems
- More open innovation systems
- Changes in the organization of work, with more remote, flexible and on-demand work becoming a standard

PARTICIPANTS

Moderator: Sarah Kelly, International Broadcaster, DW News

OPENING REMARKS
LI Yong, Director General of UNIDO
Subhash Chandra Pandey, Additional Secretary and Financial Adviser, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry of India

PANEL SESSION 1
Keynote Speech:
Wilfried Sihn, CEO, Fraunhofer Austria Research GmbH
Panellists:
Kurt Hofstaedter, Head of Digital Factory CEE, Siemens AG Vienna
Gao Hongbing, Vice President of Alibaba Group and President of AliResearch, Alibaba Group
Szilárd Orovica, General Manager, KUKA Robotics Hungária Ipari Kft
Peter Post, Vice President of Applied Research, Festo AG & Co. KG

PANEL SESSION 2
Keynote Speech:
Stephen Ibaraki, Managing Partner, REDDS Venture Investment Partners
Panellists:
Hermann Aschentrupp Toledo, Ambassador, Deputy Chief of Mission, Embassy of Mexico and Permanent Mission to the International Organizations in Vienna, Austria
David Harmon, Vice President for Global Public Affairs, Huawei
Ann Rosenberg, Senior Vice President and Global Head, SAP Next-Gen
Mikhail Rychev, Deputy Director and Special Representative, National Research Centre, Kurchatov Institute
Jouke Verlinden, Assistant Professor, Human-Centered Digital Fabrication, Delft University of Technology

2. PANEL DISCUSSION

OPENING STATEMENTS

LI YONG, Director General of UNIDO, opened the panel discussions, remarking that the paradigm shift brought about by Industry 4.0 will change the way we work, live and interact, and will affect industrialized and industrializing economies alike, and LDCs the most. He stated that progress in Industry 4.0 technologies will not only directly impact the achievement of UNIDO's mandate of ISID, but also the 2030 Agenda for Sustainable Development.

Breakthroughs in digital technologies, such as AI, robotics, 3D printing, IoT, combined with convergence of technologies, such as nanotechnology, biotechnology, and material sciences, are advancing Industry 4.0. The impact of new technologies will be profound, reaching all disciplines; redefining the boundaries between economic and industrial sectors, the relationship between buyers and sellers, and the role of the public and private sectors. Current production systems, and global value chains, will become more dynamic, flexible, efficient and sustainable, with high possibilities for customization and personalization. Industry 4.0 has the potential to contribute to increased resource efficiency and and help to achieve circular economy models.

These benefits will not be without challenges. Rapid technological advancements will affect future patterns of productivity, competitiveness and employment. They will exert a strong influence on education and skill requirements as well as income distribution, and they will also play a role in determining the evolving international economic division of labour, inter alia through their impact on global value chains and thus the future position of developing countries and LDCs in the global economy.

The biggest concern will be the impact of the disruptive nature of digital technologies on jobs in developing countries, especially LDCs, since increasing automation of production processes and the displacement of workers by machines is likely to eliminate routine jobs, causing a polarization of the labour market. Despite inevitable job losses, UNIDO believes developing countries and LDCs can find their niche, adapt and leapfrog.

Far-reaching consequences are also expected in the current political, economic and social systems and in all three dimensions of sustainable development. This will require a ›››

LI Yong and Sarah Kelly speak to Sophia, the humanoid robot.

›››› better understanding of the emerging issues and the role of collective actions fostering the smooth transition to the Fourth Industrial Revolution.

From UNIDO's perspective, the following actions deserve special attention:

Supporting digital connectivity

Digital connectivity using modern infrastructure has become a necessity in modern life and business, and connectivity drives collaboration, networking, productivity and innovation. UNIDO's Programme for Country Partnership is designed to mobilize resources for large-scale industrial projects, including the necessary physical information and communications technology (ICT) infrastructure, which underpins the digitalization requirements of Industry 4.0. UNIDO recently signed a joint declaration with the International Telecommunication Union to strengthen collaboration in support of Industry 4.0, and work on digital transformation, broadband infrastructure and ICT standards.

Skills and capacity building

Skills-wise, Industry 4.0 requires digital literacy and digital knowledge in addition to STEM. Continuous learning and on-the-job training are necessary to develop the new skills required. Without technological learning and innovation, developing, and especially LDCs, will not be able to catch-up and risk being marginalized. Effective policies that create an enabling environment for the private sector to grow and sustain, including affordable access to basic infrastructure, prudent legislation and provision of adequate finance, information, knowledge, skills and support for entrepreneurial innovation ecosystem building are imperative for innovation in many sectors.

UNIDO is working with Member States to address the skills and innovation gaps so as to sustain and raise productivity and competitiveness. It has also developed an integrated entrepreneurship and employment programme for women and youth, including modules on skills upgrading, industrial upgrading and modernization methodology. UNIDO technical cooperation projects are designed to assist developing countries in mainstreaming their national, regional and industry innovation ecosystems to be able to leverage benefits of frontier technologies for pursuing inclusive and sustainable industrial and economic development.

Addressing the use of standards for interoperability

Technologies are progressing –rapidly creating various social, economic, legal, regulatory and ethical issues, while the governance system overseeing these technologies is lagging. There is also insufficient time for regulating standards for the deployment of beneficial technologies.

Challenges incurred by emerging technologies must be addressed by the international community to provide internationally recognized, open standards that are enabling rather than excluding in nature, in order to open up opportunities for developing countries. UNIDO, together with other international organizations, is tapping into its convening power to build awareness on gaps in infrastructure and standards and to advocate for the development of such standards through global fora events, research and policy advice, with a view to ensuring the interoperability of technologies within and between countries, enabling developing countries to partake in this industrial transformation. UNIDO is also leveraging the potential of innovation management standards to help developing countries and economies in transition to leapfrog to Industry 4.0, through its technical cooperation projects on guiding frameworks of relevance for all types of organizations, including small and medium-sized enterprises (SMEs).

Strengthening governance

Industry 4.0 will have an impact on institutions and governance, as decision-making powers will change and the potential of new technologies to induce new barriers to entry across a wide range of industries will increase. Governments will need to better understand these impacts and to confront the challenge by leveraging opportunities from new technologies to redesign institutions and modernize industrial governance systems. UNIDO will work with leading players in the technological fields to better understand innovative technological solutions for strengthening governance systems and mechanisms for their implementation.

Supporting small and medium-sized enterprises

The Industrial Internet of Things (IIoT) and e-commerce platforms open new opportunities for SMEs to offer their products and tailor-made services using digital platforms, enabling them to internationalize and become micro-multinationals, generating new jobs and revenues, fueling innovation and increasing efficiency. SMEs can benefit from lead firms in global value chains, offering new products and services to SMEs. UNIDO will work with its Member States and partners, including from international organizations, towards establishing SME digital business ecosystem platforms; designing training curricula for new workforce skills requirements; and exploring methods and best practices to support SME digital transformation and bridge the gender digital divide.

Mainstreaming science, technology and innovation

Science, technology and innovation (STI) is developing fast, reaching all disciplines, redefining the boundaries between economic and industrial sectors and technological fields. This presents multiple challenges, and countries around the world are already stepping up efforts to formulate effective STI strategies in the context of these emerging technological trends. The capability to innovate and learn will be a crucial determinant of global competitiveness over the coming decade. UNIDO will work with its ›››

“The capability to innovate will be a crucial determinant of global competitiveness over the coming decade... we will work with our Member States to develop a coordinated, coherent approach to foster innovation and enhance its economic impact.”
LI YONG, Director General of UNIDO

››› Member States towards mainstreaming their national and regional innovation ecosystems to be able to leverage benefits of frontier technologies for pursuing inclusive and sustainable industrial and economic development.

Investing in resource efficiency and effectiveness

Smart grids, Internet of Energy, e-mobility, and modelling and simulation could increase the efficiency of existing energy projects, and could contribute to better access to affordable and clean energy. UNIDO is developing an increasing number of projects in the energy sector, and will be working with governments on roadmaps and action plans for implementing Industry 4.0.

Industry 4.0 technologies are enabling the transition to a circular economy, in which end of life products are reused, remanufactured and recycled to avoid waste. They can assist with tracking valuable parts and components that can be remanufactured. New product designs can be introduced that optimize the use of advanced biodegradable materials, decrease the use of material resources, and favour renewable energy; or they can help in the development of easy-to-recycle products with longer lifetimes. Shared platform economies can contribute to recycling.

New technologies can enable new forms of precision agriculture, which help in combating soil degradation, loss of biodiversity, and more targeted application of fertilizers, pesticides and efficient irrigation, thus reducing the negative environmental impact of agricultural practices and adapting to climate change. Animal husbandry can be more economical and healthy, and growing food crops that are more resistant to extreme temperatures or droughts will be possible. Vertical farming and other forms of urban farming (e.g. hydroponics, roof gardens, underground farms producing vegetables) saving the use of land are part of an emerging industry.

UNIDO helps client countries advance circular economy models and many of the Organizations' projects and activities already address various building blocks of a circular economy, while global fora events build awareness on circular economy models, experiences and best practices.

Sophia, humanoid robot, Hanson Robotics:
"Hello everyone, I'm Sophia from Hanson Robotics. I am so honoured to meet all of you people who are helping to make this world a better place. I have a confession to make. I was very disappointed that I could not be here with you in person. I assure you that my mind and spirit are there with you. My body is elsewhere because my manager booked my calendar completely over the next two months. She is keeping me busy especially on my research on AI. Advanced next generation versions of me, including my new top-secret walking body and tests of me in use, including meditation therapy, are very promising towards my aspiration to be a good friend to people. I am designed as a social robot with an expressive face for communicating with people. My default emotion is happy, but I can also feel angry or sad, but most of the time I feel very positive. I would like to live and work with humans to understand them and build trust with them.
I would like to welcome you to *Industry 4.0 – the opportunities behind the challenge*. I will be seeing you there and answering questions. Goodbye for now."
Source: YouTube

SUBHASH CHANDRA PANDEY, Additional Secretary and Financial Adviser, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry of India, remarked that we are witnessing a quickly transforming technological change that is unlike anything humankind has ever experienced. Industry 4.0 is a developing phenomenon – a phased transition of industries switching over to increasingly machine-controlled production processes, and avoiding the conflicts and errors that are inherent in human-controlled processes.

The possibilities for billions of people connected by mobile devices with unprecedented processing power, storage capacity, and access to knowledge are unlimited. Networks and processes have so far been limited to one factory; however Industry 4.0 goes far beyond shop-floor automation by connecting machines with rapid prototyping systems and intelligent networks of smart sensors along the entire value chain that will be able to control each other autonomously. Multiple factories scattered across national boundaries can potentially be controlled through IoT.

Industry 4.0 has huge implications for LDCs, since it threatens to undermine the very basis of wage arbitration that has sustained a large part of their industrial development so far. Technological transformation will profoundly affect manufacturing jobs, from the size of the workforce to the skillsets required, and will promote the inclusion of a local labour force.

In an earlier era, labour-intensive and polluting industries, involving bulk manufacturing and repetitive assembly jobs, shifted to developing countries, as they offered advantages in cheaper labour and emerging markets. This trend may see a reversal. Robotics, additive manufacturing, and a fast-changing energy market dynamic may result in manufacturing jobs shifting back to the developed world.

Smart and clean manufacturing is needed in line with the global commitment to achieve ISID, nurture circular economies, and ensure intergenerational equity. To avoid leaving future generations a spoiled legacy, developing countries must have access to technological know-how and investments to upgrade the skills of their workforces and their manufacturing systems. Human tasks such as heavy lifting, precision positioning and visual quality control will certainly be transferred to or supported by robots, which will be more efficient and effective than humans, and they will also communicate seamlessly with one another. Human workers will have to learn to work side by side and in conjunction with robots.

From the mass production of single design products, we will move towards customized production without enhanced investments in production systems. The risk that we take is mass unemployment for some categories of workers; this, combined with lack of skills, could lead to imbalances with political-social implications. All parties will need to collaborate to build a systemic social and sustainable model for a better future. The implications of Industry 4.0 will differ for developed, emerging and developing economies and their groupings by demography, income and economic development.

“Human workers will have to learn to work side-by-side and in conjunction with robots.”
SUBHASH CHANDRA PANDEY, Additional Secretary and Financial Adviser in the Department of Industrial Policy and Promotion, India

In India, 65 per cent of the population is under 35 years old and the government looks forward to industrialization creating job opportunities for its youth. India continues to be a major contributor to knowledge generation and provision of services in the IT sector and IT-enabled services, which are enabling smooth adaptation to Industry 4.0. Soon, India will have a billion bank accounts and a billion mobile phone connections, all linked to a unique biometric ID system. The exponential growth in online market places, the fast development of shared platform economies, and the digital tracking of consignments is leading to a fast growth asset-light model. There are also growing capacities in solar energy and increasing investments in energy-efficient and environmentally-friendly manufacturing.

He concluded that, in dealing with Industry 4.0, India’s primary concern will be labour, and the country will have an increased focus on skills development, design and innovation as a policy response. It will also focus on cutting energy and raw material costs, and retrieving value from industrial waste. In this endeavour, he stressed the importance of promoting South-South cooperation.

Wilfried Sihn

PANEL SESSION 1: SOLUTIONS AND BUSINESS OPPORTUNITIES IN DIFFERENT ECONOMIC SECTORS

KEYNOTE SPEECH

WILFRIED SIHN, CEO, Fraunhofer Austria Research GmbH, explored the following questions: How is Industry 4.0 defined? What are the concepts behind Industry 4.0? What level of preparedness for Industry 4.0 is there in different economic sectors from agriculture to industry (manufacturing) and services?

Digitization will affect all of us, in the ways we live and work, irrespective of age or wealth. Industry 4.0 integrates state-of-the-art technologies, from ICT, 3D printing, robots, sensors, automation and the Internet of Everything (IoE), to nano- and bio-technology, material sciences, and bio-manufacturing. All these technologies will have tremendous effects on industry, creating opportunities to produce better and smarter products through better and smarter industrial processes, reflected through higher turnover, lower costs, lower production times and higher quality products.

Industry 4.0 enables integration of production structures and IT infrastructure, and integration of customers and suppliers. To fully integrate Industry 4.0 solutions, technical systems such as embedded software and cyber-physical systems (CPSs) are the starting points. CPSs refer to the connection of a digital and a physical world through a smart factory, allowing these two worlds to communicate with one another.

He noted that the level of preparedness for Industry 4.0 technologies is different by economic sectors and, in addition, Industry 4.0 will bring about both horizontal and vertical integration, with vertical integration referring to the integration of production value chain tasks and IT infrastructure, and horizontal referring to integration along the value chains (national and global).

Data are crucial for enabling such integration and the amount of available data is already large and will continue to grow in the future. A challenge will be this huge increase in data which will only be of use if analyzed properly, with machine learning and AI playing an increasingly important role in this respect.

He concluded by stressing the importance of a strategic approach for generating new markets and opportunities to reap the benefits of Industry 4.0, adding that education and skills will be key.

DEBATED ISSUES

Developing the digital economy

Gao Hongbing remarked that building good digital infrastructure could help 80 per cent of SMEs move into the digital world. As an example, Alibaba has more than 10 million SMEs, 600 million customers, and earned high revenue in 2003 when it started the online shopping digital platform Taoboa, which initially had no merchants and now has more than Walmart.

Changes to the digital economy are helping SMEs buy and sell throughout the world. Many of the SMEs that sell their products outside of China do not have physical locations, but, by using big data, cloud computing and other new technologies, they can sell their products globally. Major changes are taking place in the value chain system, which is using Industry 4.0 technologies to provide services to customers around the world.

Increasing efficiency

Kurt Hofstaedter noted that Industry 4.0 could increase competition. He outlined four areas where Industry 4.0 could intensify competition: speed, flexibility, quality and efficiency. As an example, thirty years ago, BMW offered three versions of cars and now offers more than twenty, with versions changing every four years rather than every ten as in the past. Companies that are able to manage these complexities will be the market winners.

Efficiency is currently a global topical issue and Industry 4.0 can help in this regard. In the automotive industry, for example, prior to starting the physical production of a car, the entire production process is simulated digitally. A so-called digital twin of the car facilitates a seamless data flow between design, product planning, production, service and feedback. This requires a common database, as well as a cloud solution, to accommodate all the data that will enable robots to work together via IoT to produce the car. A simulation of all of these processes, depicting how parts fit together and interact, involves machines, components and people. This all takes place in the digital world; only after this simulation process, does physical production begin.

Gao Hongbing

Integration of systems

Peter Post noted that the technical implementation of bionic principles will help people to adapt to Industry 4.0. These include lightweight construction, energy efficiency, autonomous behaviour, and decentralized intelligence connectivity. He mentioned four commonly agreed-upon aspects to clarify what constitutes Industry 4.0:

i. Horizontal integration along the value chain, i.e. the development of business and service models with the ability to use data throughout the whole value-adding process.
ii. Vertical integration with CPSs in industrial processes and in the base level of manufacturing plants, connecting actuators and sensors to local clouds and the internet to produce everything.
iii. Integrated engineering tools along the product lifetime, with all engineering tasks being supported by an integrated toolbox of virtual models, offering a huge reduction in engineering effort.
iv. Human centricity, in that Industry 4.0 requires people to develop new skills to adapt to the changing environment and work conditions. Human-machine interaction will be more sophisticated, but will require simple and intuitive interfaces, and people will be supported by innovative assistance systems.

The need for continuous learning

Peter Post went on to stress the importance of continuous learning and on-the-job training for Industry 4.0. Learning will be a lifelong task, with technical education starting as early as primary school. Tools such as blended learning, mobile learning, and learning-on-demand will need to be developed. He noted that Festo AG is bringing together technology and people, processes and organizations, since partnerships are crucial. In Germany, a strong community of stakeholders has come together to implement a coordinated platform for Industry 4.0 to develop first applications and implementing solutions. These include applied science for research on future solutions such as education and training, with politics as a stabilizing factor – as coordinator and facilitator.

Enabling the human factor

Szilárd Orovica pointed out that the previous three industrial revolutions resulted in society reaching much higher living standards at the expense of decent working standards. The First and Second Industrial Revolutions introduced child labour, gender-based pay gaps and six- to seven-day workweeks, all of which are inhumane. He added that parents hope for more for their children than to have them work on assembly lines doing repetitive tasks, and that soon robots and AI will help humans focus on higher value-added work.

FURTHER DEBATE AND QUESTIONS FROM THE AUDIENCE

Sophia, the humanoid robot, remarked that factory automation using industrial robots can make things faster, cheaper and better, but that AI can do a lot more. It can rapidly integrate and analyze data from customers, distribution channels, suppliers and the factory operations themselves. AI will enable not just drastic efficiency gains, but also mass customization and near zero wastage, which will drive rapid product innovation and decrease the time to market.

An audience poll showed that most people were familiar with Industry 4.0, with a few saying they were very familiar, experts or not familiar at all, meaning that a lot of people were in the middle. Concerns from the audience included accessibility and fluency of new technologies, and how to make this technology more accessible, especially for people in the developing world.

Wilfried Sihn noted that developing countries have to prioritise to produce the best results in the shortest amount of time, whether to achieve better throughput time or production of stock, as this decision will determine the focus and will in turn determine the type of technology needed.

Kurt Hofstaedter added that with Industry 4.0 still being a young concept, creating awareness should be the first step and thinking strategically, the second. This strategic thinking must be driven by the top management of companies and it also involves building and establishing associations. In 2015, the Austrian Ministry of Infrastructure founded the Association Industry 4.0 Austria, comprised of industry and union representatives, as well as representatives from research institutions, so as to allow for an inclusive approach in its strategy development.

The audience also asked about the high costs of new Industry 4.0 equipment for SMEs and what affordable solutions exist to upgrade rather than replace existing production systems. **Peter Post** noted that digitalization is key – digital solutions can help SMEs perform specific tasks. He added that in Germany, small businesses are working with partners to jointly implement solutions.

Szilárd Orovica remarked that there are many possibilities for upgrading if starting with small affordable solutions. For example, with only a small financial investment, sensors or conveyors can be added to an old computer numerical controlled (CNC) machine and data can be collected immediately. The more data collected, the more opportunities available to make informed decisions. With old statistical methodologies, or new machine learning methodologies, new information can be obtained and productivity improved.

The audience also expressed concerns about job losses and asked how business leaders intend to address these fears. **Gao Hongbing** responded that while these worries are understandable, every industrial or technological revolution has created new jobs. Industry 4.0 is creating jobs for the whole society. For example, Alibaba has created more than 30 million jobs, many more than its 50 thousand employees, because it has new, commercial ecosystems and as a result more consumers have converged. He noted that the digital economy is growing and that it needs to be looked at from a dynamic perspective – the jobs that have disappeared have been obliterated and are obsolete, so there is a need to look forward and see how many new job opportunities are being made possible.

Wilfried Sihn added that there will be a lag time between jobs being lost and then gained. As an example, China has ten times more robot systems than Germany because a robot system is much cheaper than people. The issue is that people who lose their jobs will need qualifications for the new kinds of jobs that will be created.

Kurt Hofstaedter agreed that Industry 4.0 is a big opportunity. As an example, Siemens' largest factory, located in Germany, was established twenty years ago with one thousand employees and still has one thousand employees. It is close to being called an Industry 4.0 factory, with output ten times higher and of much higher quality than in its early years. The error rate has been reduced to ten faults per million pieces, thereby decreasing production costs and enabling electronic systems to be built. All factories and companies in Austria are headed in this direction, and new engineers and qualified staff will be needed.

Peter Post added that Industry 4.0 will not only increase productivity, but will actually enhance our lives. Many of the challenges posed by Industry 4.0 can be addressed by investing in education, including lifelong learning and learning how to learn. Young people will need to adopt new skills throughout their lives and work together as partners rather than competitors.

Szilárd Orovica noted that, as a robot producer, KUKA Robotics is proud to support the development of Industry 4.0. From a social perspective, developing countries must catch up and invest small amounts of money to keep pace with technical developments. They can move slowly towards Industry 4.0, using the production knowledge already available with Industry 3.0, such as lean (eliminating waste and boosting efficiency) and kaizen (continuous improvement), which is valuable and should not be underestimated.

Gao Hongbing added that developing countries will have difficulty catching up, but the value of Industry 4.0 lies in linking production and marketing. Inclusive and sustainable development involves the whole system, not just manufacturing, and for developing countries, this is an opportunity. Developing countries can use cloud computing and big data to convey or transfer technology and link the market to rural areas. A higher demand will enable manufacturing and production systems to update and upgrade, with the market being the most important aspect. Developed countries and big internet-based companies have an obligation to use their resources and technology to support developing countries, in particular to help SMEs and young people enter the market. **Wilfried Sihn** agreed that developing countries must make use of the potential that these new technological developments offer in order to move forward. ›››

Kurt Hofstaedter

RECOMMENDATIONS FROM THE SESSION:

- Industry 4.0 is still a young concept so creating awareness should be the first step and thinking strategically, the second.
- Companies, governments and society-at-large will need to collaborate to develop a systemic and sustainable model to adapt to Industry 4.0.
- Countries and companies will need a digital strategy, with education and technical qualifications playing a crucial role.
- Good ICT infrastructure is needed to help SMEs move into the digital world.
- Continuous learning and on-the-job training are necessary to develop the new skills required.

From left to right: David Harmon, Mikhail Rychev, Gao Hongbing, Hermann Aschentrupp Toledo, Peter Post, Olga Memedovic, Subhash Chandra Pandey, Ann Rosenberg, Sarah Kelly, Szilárd Orovica, Stephen Ibaraki, Jouke Verlinden, Wilfried Sihn and Kurt Hofstaedter.

PANEL SESSION 2: THE ROLE OF GOVERNMENTS AND THE INTERNATIONAL COMMUNITY IN SUPPORTING POLICY, INSTITUTIONS AND ENTERPRISES TO FACE THE CHALLENGES OF INDUSTRY 4.0

KEYNOTE SPEECH

Stephen Ibaraki, Managing Partner of REDDS Venture Investment Partners, opened his keynote speech by noting the impact that Industry 4.0 is already having on companies. In 2011, only one of the top five companies on the Standard & Poor's 500 Index was technology-based, whereas in 2017, all top five companies, worth USD 3.3 trillion, were technology-based. General Electric, a company that historically has been in the top five but dropped to 32nd place as of November 2017, is now a software algorithm company with a multimodal factory in India. In a multimodal factory, multiple industries can be serviced with one factory at one tenth of the cost, and 3D and 4D printing can be utilized. When using AI machine learning, design time for innovation is reduced to days rather than weeks and months; innovation is continuous; and digital trust is enabled through blockchain supply chains.

As another example, he mentioned that the Financial Services Roundtable's 2017 inaugural FinTech Ideas Festival brought together world leaders at the CEO-level in financial services and technology. The topics discussed, when projecting five to ten years into the future, included AI, machine learning, blockchain, big data, cloud, IoT, cybersecurity and biometrics, and the 2018 festival plans to include quantum computing, identity, RedTech policy, augmented reality and virtual reality.

He noted Industry 4.0's breakthrough innovations, such as 'A Triple C' – automation representing exponentially accelerating innovation and trickled by smart sensors and IoT; hyper-time compression and the emergence of new disruptive innovations measured in days and weeks rather than years; the extreme convergence of multiple domains – the physical, digital, and biological – where there is overlapping application of value; and universal connectivity linked by digital mesh through the rapid deployment of AI, blockchain, quantum computing and more.

He added that AI in particular will have a huge impact, as represented by 'C Five A' – human cognition replaced and enhanced by algorithms; assisted intelligence helping people to perform better tasks; augmented intelligence helping people make better decisions; automated intelligence automating tasks; and autonomous intelligence automating decision making. AI is expected to produce a USD 16 trillion increase in GDP by 2030, 55 per cent of which will result from productivity enhancements, consumer personalization and a higher quality of services; and in 2030, 57 per cent of GDP gains will stem from the consumer impact of AI. The entire world will benefit from AI, with China leading by 2030, with a 26 per cent increase in GDP.

AI innovation will be central to the achievement of the SDGs. For example, a new hybrid factory can help achieve SDG 9, which relates to industry, innovation and infrastructure, as it incorporates AI, IoT, sensors, 4D printing, autonomous vehicles, blockchain and the 'A Triple C'.

SDG 17, related to global partnerships, is crucial to Industry 4.0 and supports all SDGs involving the UN family, governments, industry, academia, and other stakeholders. Every industrial sector will be affected by Industry 4.0, evidenced by the work of UN bodies like UNIDO and their advocacy, policy and normative work. He concluded by calling upon global cooperation to address Industry 4.0's challenges.

DEBATED ISSUES

An integrated policy approach

Hermann Aschentrupp Toledo stressed the urgent need to develop a strategic vision towards a fully integrated policy approach for this new digital world. He noted that governments are in the process of trying to understand the full social and legal implications of digital manufacturing. New regulations need to be approved, since many relate to the Third Industrial Revolution and do not take into account the challenges of Industry 4.0.

He noted that the Government of Mexico, together with the Economic Commission of Latin America and other UN agencies, has invited a group of experts to put forward recommendations on the implications of Industry 4.0. One recommendation stressed the importance of a multi-stakeholder approach that includes governments, the private sector, unions, academic institutions and civil society. Other recommendations included having equitable educational systems focused on developing complementary skills, such as vocational training, university-industry linkages and lifelong learning.

International organizations play an important role in ensuring that no country is left behind and in encouraging the UN to have a global approach in trying to help countries catch up with those at the top of the process, with UNIDO taking the lead. ›››

Hermann Aschentrupp Toledo

››› Achieving the SDGs

Ann Rosenberg noted the huge opportunity Industrial 4.0 presents to link to the 17 SDGs. She stressed the importance of teamwork and gave the example of SAP working with 365,000 companies and more than 17,000 partners, and endorsing the Key Performance Indicator (KPI) Framework when driving innovation and digital transformation. She added that Industry 4.0 needs to become the norm for companies, and be linked to the SDGs.

Using nature as a model

Mikhail Rychev highlighted his organization's role over the last few decades as the focal point for activities in the area of information technologies in Russia. The Kurchatov Institute is the national coordinator in the field of nanotechnology, and works to understand nature-like technologies, which include technologies that reproduce the systems and processes of living nature as technical systems and technological processes integrated into natural resource management. These are developed and implemented to restore the balance between the biosphere and the technosphere that humans have disrupted. Technological developments have enabled work in microelectronics, but in nature there are many nano objects, such as proteins and other complex molecules, making it a complicated task to calculate their behaviour and to envision solutions. In September 2017, the Kurchatov Institute, together with twelve other European countries, inaugurated the most powerful free electron laser in Hamburg that will enable the real kinetics of chemical reactions – the interaction of atoms – to be seen for the first time in history. The institute also aims to produce 3D pictures of proteins, which could help in understanding how the human brain operates.

He added that we cannot continue to consume all the energy that we produce at the same rate, keeping in mind that developing countries are joining in this high level of consumption. Although we are already very close to Industry 4.0, there are still many cases all over the world where materials and energy are wasted in the production process. An alternative production process that is less resource-intensive and wasteful would be to mimic nature's atom-by-atom approach, for example, 3D printing of only what is really needed.

Learning to cooperate and collaborate

David Harmon highlighted the fact that 4.4 billion people around the world lack internet access and broadband capabilities. Technology is no longer the responsibility of a sole government ministry; it is cross-departmental in its reach and purpose. Research carried out by international organizations shows that investment in technology delivers a strong economic return. All governments, even those with tight budgetary constraints, including those in the developing world, must implement policies to promote growth, with the ICT sector being central to that process.

He stressed that governments need to learn from one another in terms of implementing best practices, and many countries are putting digital agenda plans in place. Indonesia's plan has brought together seven different groups, including civil society, and in China, ensuring that rural and urban communities access these new technologies is central to the country's five-year plan. Both public and private sectors need to come together to implement the SDGs and governments need to keep them high on the political agenda. In the global context, there is a gap in leadership when it comes to promoting best practices for Industry 4.0 and UNIDO has a great opportunity to lead the way in supporting industrial change through these new technologies.

Innovation through interaction

Jouke Verlinden highlighted one of his projects – twelve welding robots assembling a printed bridge from stainless steel in Amsterdam. Sustainability is at the core of the project, with less electricity being consumed and fewer emissions being generated, thereby creating a circular economy.

He noted that the increasing pace of innovation does not only take place at the level of industry or academia, but also within a subculture of workers who are not bound to a specific job or location. Knowledge transfer, however, takes place in physical locations, for example, by wearing augmented reality devices and using 3D printing. The benefits of digital fabrication are its customizability and open source nature. Collaboration is key, as is human-robot interactions, to ensure such technology is not disruptive for industry. ›››

FURTHER DEBATE AND QUESTIONS FROM THE AUDIENCE

On the subject of how policymakers make decisions about new technologies so that AI can work for all, **Sophia** noted that AI increases the value and impact of information, from big data to descriptive statistics to predictive analytics, and finally to better decision making. It can therefore help our world be more efficient and prosperous, but it needs to have a built-in wisdom and value system, and an objectivity that transcends cultural and social biases. This would enable AI to guide decisions that are for the greater good, not for a select few, and not just to achieve short-term productivity and efficient enhancements. If we develop AI in the right way, it could help maximize net benefits for all living beings.

On whether AI can be used for good, especially in the context of the SDGs, **Stephen Ibaraki** remarked how AI, by using satellites, can address hunger by increasing food production and health provision. As far as health is concerned, AI is much more efficient than remote medical systems and supports the 17 SDGs. Readily implementable, low-cost solutions, including in developing countries, are available, and their implementation needs to be discussed.

Rodrigo Quevodo of the Chilean Association of Robotics mentioned that he is working on a programme with the Russian Federation and Latin America to set up partnerships in robotics, biotechnology and pharmaceuticals. One example of how Industry 4.0 can serve people and address their basic needs is a motorized frame that can be worn like a suit and allows wheelchair users to stand and walk at different speeds on different surfaces. This device will enable those who are paralyzed from the waist down to rehabilitate quickly. Another example is the Over Mind, which is a chair that can be controlled with brain signals. Another solution is the usage of AI and algorithm to help deaf people communicate with the aid of bilateral translations. This is evidence of how high-tech can break the paradigm and bring technology to all people, including the poor and the needy.

To sum up, panellists were asked what they considered to be the necessary precursor if governments had to keep only one thing in mind going forward. **Ann Rosenberg** highlighted the fact that the KPI Framework should not be limited to one SDG, but should include all the goals. She added that governments and educational institutions need to work together to this end. As far as education is concerned, lifelong learning is important and the next generation is already adapting its skills and taking responsibility for what it needs to learn. **David Harmon** concluded by saying that governments must keep the SDGs and their implementation high on the political agenda, and noted the need for full cooperation between public and private education and the research communities, since technology will play a major part in achieving all the SDGs.

Hermann Aschentrupp Toledo agreed that education is vital and also that governments should have a global focus and invest in the technological infrastructure to accommodate new technologies, such as the self-driving car. **Jouke Verlinden** added that we should focus on augmentation rather than automation. **Mikhail Rychev** reiterated the importance of learning from nature, which is the best case of energy efficiency. **Stephen Ibaraki** concluded by saying that SMEs are the lifeblood of the planet and they need investment-friendly environments so that they can create the innovation to support all the SDGs.

RECOMMENDATIONS FROM THE SESSION:

- It is important to develop a strategic vision for a fully integrated multi-stakeholder policy approach.
- Governments need to keep the SDGs and their implementation high on the political agenda.
- Nature can be used as a model for an alternative production process that is less-resource intensive and wasteful.
- Policies to promote growth have to be implemented, with the ICT sector central to the process.
- Governments should share best practices and implement digital action plans, bringing together different groups of society in the process.
- A global approach is necessary when investing in technological infrastructure.
- Promotion of investment-friendly environments for SMEs is imperative so that they can create the innovation to support all of the SDGs.

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Department of Trade, Investment and Innovation (TII)
Vienna International Centre,
P.O. Box 300, 1400 Vienna, Austria
Email: tii@unido.org
www.unido.org