



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION



Industry 4.0

Opportunities and
Challenges of the New
Industrial Revolution for
Developing Countries and
Economies in Transition

Panel discussion



TOGETHER
for a sustainable future

Fifty years ago, in 1966, the United Nations General Assembly adopted a resolution establishing the **United Nations Industrial Development Organization (UNIDO)**. UNIDO is the UN system's industrial development arm, and continues to work to eradicate global poverty by assisting developing and middle income countries in achieving inclusive and sustainable industrial development.

To celebrate its 50th anniversary, UNIDO organized a series of events from 21 to 25 November 2016 at its Vienna Headquarters. The week-long celebration was attended by some 1,600 participants from over 190 countries, including high-level representatives of UNIDO's 170 Member States, as well as leaders of international organizations and the private sector, and leading figures from academia. Around 300,000 people from all over the world took part in the celebrations via our social media channels, and were able to join us directly through the live streaming of selected events.

In total, 28 events were organized in the course of the week, including panel discussions and presentations, as well as food festivals and cultural performances. The events featured 155 speakers and focused on topics such as the way forward in achieving the 2030 Agenda and Sustainable Development Goals; financing for development; industrial development for job creation to address root causes of migration; the Fourth Industrial Revolution and its implications for developing countries; and climate change.

Industry 4.0 is one of the major drivers of the Fourth Industrial Revolution. The first industrial revolution was triggered by water and steam power to move from human labour to mechanical manufacturing. The second industrial revolution built on electric power to create mass production. The third used electronics and information technology to automate manufacturing. The fourth is the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Industrial Internet of Things (IIoT), and cloud computing. Industry 4.0 is gradually implemented, often with digitalization as the first important step. Digital technologies allow for new business models and value-producing opportunities, and are attainable for most developing countries.



SYNOPSIS

This event, that took place on 23 November 2016, on the occasion of UNIDO's 50th Anniversary, debated the **Industry 4.0**, which is a major driver of the Fourth Industrial Revolution, also referred to as the New Industrial Revolution (NIR). The panel discussed how UNIDO, and the development community at large, could help developing countries and economies in transition address opportunities and challenges stemming from the Fourth Industrial Revolution in the context of 2030 Agenda and the Sustainable Development Goals (SDGs). This included new innovative approaches to climate change mitigation; development of the circular economy; the role of strategic partnerships; the role of agreed standards for the exchange of data and components in the digital ecosystem; data security and privacy issues; loss of jobs; and digital gaps.

The panellists highlighted the necessity for pro-active skills transformation, both in the educational system and in the workplace, emphasizing the role of the younger generation - the 'robotic natives'. They foresaw that humans in the future will need to learn to coexist and collaborate with intelligent machines in the workplace, and stressed the need for partnership for innovation and technological learning, highlighting UNIDO's role as catalyst in this area.

The key conclusions from the expert discussion were:

- ▶ The importance of building awareness of the Industry 4.0 consequences for inclusive and sustainable industrial development (ISID) and providing access to know-how, skills, education and technology.
- ▶ The great potential of innovation management standards to help developing countries and economies in transition to leapfrog into Industry 4.0. These guiding frameworks would be relevant for all types of organizations, including SMEs.
- ▶ The potential of UNIDO to assist in establishing multi-stakeholder knowledge sharing platforms to create awareness on Industry 4.0 opportunities and challenges for pursuing ISID in developing countries; for sharing available tools and methods for innovation management; designing training curricula for new workforce skills requirements; exploring methods and best practices to support SMEs digital transformation and bridging the gender digital divide; building awareness among policy makers and industry associations on the issues of new infrastructure, standards and policies that need to be developed or mainstreamed to correspond to the new technologies.

INTRODUCTION

Several advanced economies are implementing the concept of Industry 4.0, marking the Fourth Industrial Revolution. Increasingly, companies are applying innovative solutions, including through the “Internet of Things” (IoT), cloud computing, miniaturization, and 3D printing that will enable more interoperability and flexible industrial processes and autonomous and intelligent manufacturing. The physical components of industrial production are being transformed by smart, digital networking into cyber-physical systems (CPS), allowing for the management of production processes in real-time across great distances and customized products.

Industry 4.0 has the potential to improve productivity and competitiveness, increase energy and resource efficiency and effectiveness and hence to protect the environment. It could, further enable the transition to a circular economy, or industrial economy in which end of life products are reused, remanufactured and recycled. Taken together, these developments would lead to the emergence of more sustainable production and consumption patterns, and could thus provide opportunities for developed and developing countries to achieve economic growth and sustainable development in line with the 2030 Agenda for Sustainable Development.

The consequences of Industry 4.0 on employment, wealth creation and distribution, are not fully understood. One of the biggest concerns is the impact on jobs in developing countries. Increasing automation of production processes and the displacement of workers by machines is likely to eliminate routine types of jobs, decrease demand for cheap labor in low-end manufacturing, increase inequality, and cause migration. A global net decrease in jobs could be especially challenging for developing countries where, unlike developed economies, millions of young people are entering the job market every year.

More than ever, developing countries and economies in transition must be made aware of implications and challenges related to this paradigm shift. For example, apart from dealing with implementation of Industry 4.0, developing countries must prepare to face the consequences of its implementation in advanced economies. Some of these consequences relate to reversed flows of foreign direct investment and a further manifestation of an already widening technology gap. While the ramifications for developing countries and economies in transition could turn out to be dire, experience tells us that economies have a remarkable adaptive ability to deal with the mechanization of production. As such, the arrival of Industry 4.0 also brings opportunities for development, for example in terms of achieving the objectives set forth in the 2030 Agenda for Sustainable Development and its associated SDGs. Importantly, among developing countries there is great heterogeneity in terms of their ability to handle the advent of Industry 4.0. Indeed, most recently, the World Economic Forum argued that some more advanced developing countries could leapfrog into Industry 4.0, and that its impact could be far reaching to possibly attaining - within a generation - inclusive and sustainable industrial development.



OPENING STATEMENT

Mr. Bernardo Calzadilla-Sarmiento, Director, Department of Trade Investment and Innovation at UNIDO, emphasized the profound impacts that Industry 4.0 will have on society, factories, households, the public sector, on advanced economies and developing economies and economies in transition. While discussion has focused on what Industry 4.0 means for developed economies, less discussion is devoted to the impact on developing countries and economies in transition. There are developing countries that are already preparing for and adopting strategies regarding Industry 4.0, such as China and India. It is therefore important to take into account their experience.

One of the important challenges for developing countries is the reversal of FDI flows. While previously FDI followed cheap labour, labour cost differentials might no longer play such an important role with Industry 4.0. Additional challenges for developing economies might be a widening technology and knowledge gap, its implications on skills, rising inequalities, and gender equality.

Industry 4.0 offers opportunities, such as increased productivity, reduced waste, and promotion of the circular economy and more sustainable patterns of production and consumption. It might thus also help to mitigate climate change.

Often, developing countries have missed earlier technology waves, resulting in large GDP and productivity gaps and therefore wide differentials in terms of welfare; failing to take advantage of Industry 4.0 risks accentuating such gaps further.

To enable developing countries to respond to the challenges of Industry 4.0, the international community has to take collective actions and pursue new innovative partnership approaches for delivering and strengthening its portfolio of services to address market failures related to the uptake of new technologies and business models.



KEYNOTE SPEECH

Ms. Eva Diedrichs, Managing Director, IMP³ROVE, European Innovation Management Academy, EWIV, in her keynote briefly explored the following questions:

1. What is Industry 4.0?
2. What is the key prerequisite to effectively embrace Industry 4.0?
3. How can this key prerequisite be developed?

What is Industry 4.0?

The World Economic Forum considers that the current paradigm change goes beyond Industry 4.0: “The Fourth Industrial Revolution....[which] is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres”. The technologies today include artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing. The crucial question is whether the combination and widespread application of these technologies would also result in a positive net effect for our economies and societies at large. Some of the challenges and opportunities of Industry 4.0 are on their way - and in some areas are moving at high speed.



What is the key pre-requisite to effectively embrace Industry 4.0?

Many will be correct in thinking that IT skills are the key prerequisite and will help to engage in automation, in Big Data Analytics, in connecting global value chains, in creating transparency in public administration, and in understanding how cyberspace will become a new dimension for governments, where traditional approaches will reach their limits.

An organization's successful entry into Industry 4.0 depends on its ability to respond to change, and master products, processes and value chains innovation on a continuous basis. Organizations with strong innovation capabilities will need to have a clear innovation strategy and a culture that translates this innovation strategy into action, and will need a well-defined yet flexible process to collect and evaluate ideas, develop them further into products, processes, services or business models.

How can this key prerequisite be developed?

Ms Diedrichs outlined the most important steps for businesses and public institutions in support of economic development:

- ▶ Create awareness of the importance of innovation in general, and digital innovation in particular
- ▶ Educate in innovation management
- ▶ Identify organizations' improvement potentials in innovation management and in digital innovation
- ▶ Take action to gain in agility by improved innovation management capabilities to embrace Industry 4.0.



OTHER PANELLISTS

Dr. Rohani Hashim, Secretary General of the World Association of International Technology and Research Organizations (WAITRO), Malaysia.

Mr. Ramachandran Sundararajan, Principal Consultant, Infosys BPO, India.

Mr. Sami Haddadin, Director, Institute of Automatic Control, Leibniz University, Germany.

Mr. Magnus P. Karlsson, Professor, KTH Royal Institute of Technology, Stockholm, Sweden.

Mr. Chunlong Liu, Counsellor, Permanent Mission of China to the International Atomic Energy Agency (IAEA).

Following the keynote, the panellists discussed the following issues.

What are the challenges of Industry 4.0 from a developed country perspective?

Indicating that Industry 4.0 also has the capacity to kill jobs and exclude parts of society, Ms. Diedrichs asked Prof. Karlsson what he sees as the challenge regarding jobs and the skills needed in the future.

Prof. Karlsson responded that Industry 4.0, including the next wave of automation, would be profoundly transformative and outlined three clusters of challenges:

1. Awareness and readiness. Uncertainty is a key factor - there is a need for experimentation and learning - and even unlearning. Companies must challenge their own business assumptions.

2. Explosion of data. Ericsson is currently exploring the fifth generation of mobile systems - 5G - which will see faster connectivity, more data being transmitted over wireless connections and to more devices. This will be the platform that connects people and things, sometimes called the Internet of Things (IoT). An estimated five billion things are already connected, a figure that will rise to almost

20 billion in five years. Building a digital ecosystem will require seamless connectivity, data sharing, and agreed standards for the exchange of data and components that are parts of systems. As data starts to accumulate and be shared, other issues come to the forefront, such as data security and privacy.

3. Workforce transformation. The shift in employment will be gradual but profound. Digital labour, such as the use of smart drones, robots and intelligent assistance will enter the workforce. New industry sectors will emerge, such as digital medicine, precision agriculture and new jobs, medical robot designers, and grid modernization managers. There will also be a transformation in existing jobs. For example, virtual reality and augmented reality will assist workers to become more productive and make their work environment safer.

Prof. Karlsson emphasised the need to deal with these challenges and reform the education system and upgrade skills in the workplace. Policy incentives are needed to encourage businesses to do this reskilling, and we must learn to collaborate and coexist with intelligent machines.



What are the challenges for developing countries?

Mr. Sundararajan replied that Industry 4.0 is a level playing field for those countries that missed the early waves of automation and industrialization, and outlined the three major challenges to developing countries:

- ▶ **Skillsets:** In developing countries reskilling does not take place. There are specific skillsets required, such as robotic programming and Big Data Analytics, and these are available in pockets in developing countries.
- ▶ **Scalability:** several enterprises are at the early stages of Industry 4.0 design and implementation. They have carried out some pilots on assembly lines, but the challenge is to scale up across enterprises and multiple factories.
- ▶ **Funding:** Funding is important but assumes more than just money. A lot of business management buy-in is required to sign up to Industry 4.0 roadmaps.



Standardization and Industry 4.0: ongoing discussion

- ▶ The uptake of Industry 4.0 technologies will be possible only when the respective technologies, interfaces, and formats have been laid down in standards.
- ▶ The consolidation of new concepts by means of consensus-based standardization at an early stage of development is absolutely essential for their uptake in industrial practice.
- ▶ The key role of standardization for Industry 4.0 is reflected in the ongoing international initiatives as follows:
 - ▶ Intensive work is being carried out at ISO/IEC and in various forums and consortia (e.g. W3C, IEEE). This work will include developing standards that ensure resource and environmental efficiency and effectiveness.
 - ▶ A proposal for the neutral reference architecture model has been made in Germany: RAMI 4.0, with the objective of setting a comprehensive framework for the conceptual and structural design of Industry 4.0 systems; organization of standard resource and environmental data.

Ongoing discussions cover the following issues:

- ▶ Value chain upgrading through the use of digital technologies, processes and products; profound changes in modularization require the use of ICT (mechatronic systems), which are being transformed into cyber-physical systems (CPS), while at the same time maintaining the current level of safety.
- ▶ Improve energy and resource efficiency, leveraging the potentials of digitalization and other Industry 4.0 technologies.
- ▶ Address the structural transformation caused by Industry 4.0, including the social and organizational challenges, caused by demographic changes in different groups of developing countries.
- ▶ Set up knowledge-sharing platforms, coordinated by UNIDO, where stakeholders can meet to coordinate their standardization activities. This will contribute to interoperability in Industry 4.0.
- ▶ Developing new standards for enabling the NIR may need to be accelerated. Ensuring that new standards work and limit the number of standards to a manageable size, will be a challenge ahead for international organizations and representatives of various countries. National standardization activities need to be harmonized with those at international level. This would include issues such as identifying which standards' organizations and which standards' projects are relevant, as well as who is to be responsible for what. SMEs need to be more involved in the standardization process and some pilot cases should be initiated and supported.
- ▶ Agree on a uniform reference architecture model for structuring further standards work. Flexible standardization combined with open source implementation should be used to ensure further strategic, conceptual, and organizational developments. An interoperable and safe IT architecture model based on international standards should be set up.
- ▶ Take advantage of the benefits of standardization at an early stage of development. Ensure that aspects of standardization are integrated into national and international research projects, and suitable standards work is initiated at the R&D stage, and standardization is taken into account from the beginning.



What are the Industry 4.0 challenges for research organizations?

Ms. Rohani Hashim mentioned that, apart from the European members of WAITRO, members in Asia have started to talk about Industry 4.0. For example, there are members in the food industry in Thailand who already have Industry 4.0 roadmaps and are also thinking of digital parks for their SMEs. In Malaysia, a survey of manufacturers found out that only 30 per cent of manufacturers are aware of Industry 4.0.

Manufacturers main concern is funding for full automation. A German-Malaysian institute has set up an i-factory for an Industry 4.0 innovation centre, which is the first learning factory to feature the latest production concepts according to German Industry 4.0 standards in South East Asia. Ms. Hashim noted the importance of government buy-in, both for financial and infrastructure support. The path to Industry 4.0 will not be the same for everyone; each country will achieve Industry 4.0 at its own pace.

What are the opportunities of Industry 4.0 and how to leverage them?

Mr. Haddadin pointed out that the Fourth Industrial Revolution is characterized by the fusion of digitalization and automation in order to make machines smart, interactive, and easy to use. These new technologies will be a central part of our lives and will have a tremendous impact on the way we work. There will be new types of robots, which are able to interact with humans. This technology will complement human activity, especially cognition, combined with other emerging technologies to give us entirely new computer models. We tend to

think of automation as classically rigid, costing hundreds of millions of dollars, but we are moving towards small-scale modular networks of connected machines that can respond to dynamic changes in requirements and therefore present entirely new possibilities of making use of automation for SMEs in Europe and in developing countries.

Skills are needed to bridge the gap between engineering and computer science, machine learning, and artificial intelligence. How we work will change and involve a shift towards higher quality jobs. There will be robotic and automation designers, intelligent system engineers, and ecosystems of automation technologies. There will be a new software business in automation.



What are the opportunities for pursuing sustainable development?

Mr. Liu pointed out that while there is no agreed definition of Industry 4.0., e-manufacturing and e-production should be part of it. The annual turnover of Alibaba Group, a company established in China in 1999, reached US\$1,000 billion in 2015, thanks to e-business. E-business is the first step, e-manufacturing and e-production are the next steps, with the help of the IoT and cloud computing. Industry will still depend on resources and energy, and every country will play a part in the production and provision of resources and energy.

To combat climate change, China has promised to reduce carbon dioxide emission intensity per unit of GDP by 60 to 65 per cent by 2030, compared to that of 2005. As part of its efforts to achieve this goal, in 2015 the Chinese government introduced its version of Industry 4.0. - "Made in China 2025". The main objective of the strategy is to ensure that China's manufacturing is innovation-driven and green. It has ten priority areas of development, including energy saving and new energy vehicles, power equipment, modern railway equipment, all of which aim to reduce carbon dioxide emission.

He gave the following examples:

- ▶ Energy-saving and new energy vehicles numbered 300,000 on the roads in China in 2015; these are mainly electric vehicles and are substantially reducing exhaust emissions.
- ▶ China has developed its own nuclear power reactor: the third generation is called Hualong No. 1. There are now 36 nuclear power reactors in operation and 20 reactors under construction. This will contribute greatly to the reduction of carbon emissions. Every year China consumes about 1.9 billion tons of coal – half of global coal consumption, mainly for electricity generation.
- ▶ China has 19,000km of high-speed railways, which is the longest network in the world. The distance between Beijing and Shanghai is about 1,200km, the same as the distance between Vienna and Paris.



Is there a role for innovation management standards to help developing countries leapfrog?

Prof. Karlsson stated that there is already a European standard available and work is ongoing regarding an international standard. These standards should be seen as guiding frameworks. The following aspects should be considered when developing a guiding framework for organizations in Industry 4.0:

- ▶ Establish an innovation strategy aligned to the digital transformation agenda.
- ▶ Set up a disciplined innovation process. Start by understanding customers' problems, move into experimentation and learning, and even unlearning, to find possible new solutions.
- ▶ Promote an organizational culture that supports innovation.
- ▶ He indicated further areas where leapfrogging could happen.
- ▶ Directly deploy digital and mobile solutions before preparing the hard infrastructure, such as in mobile banking. Digital infrastructure is also being built up rapidly in developing countries.

- ▶ Prepare infrastructure. For instance, sensors can already be embedded when building new roads, buildings and factories. The infrastructure for smart cities and smart factories can already be prepared without retrofitting.
- ▶ Benefit from lower-entry barriers for software-based products and programming. Young entrepreneurs in developing countries are writing software to reach global markets.
- ▶ Use emerging market conditions to drive frugal (and disruptive) innovation that can scale up to other markets. We see this, for instance, in prepaid mobile subscriptions, which have added five billion new subscribers.

UNIDO is in a unique position to promote innovation by:

- ▶ Creating awareness of Industry 4.0 opportunities and available standards among policymakers and industry associations (e.g. WAITRO).
- ▶ Making available appropriate tools and methods for innovation management assessment, innovation strategy, culture, etc.
- ▶ Providing training for innovation management professionals and coaches, and cross-industry communities of practice.

How can UNIDO support developing countries with regard to Industry 4.0?

Mr. Liu underlined that technical assistance on capacity building and technology transfer and absorption was an important aspect and that UNIDO has produced excellent results on the ground and in different country contexts. Technical cooperation must therefore be tailored to the context. UNIDO provides a platform for information and knowledge exchange and technology transfer, and can play an even more important role to help developing countries and economies in transition benefit from Industry 4.0.

Prof. Haddadin emphasized the importance of knowledge and technology transfer. Specific and well-designed workshops are needed to better understand the key essence of Industry 4.0 and the core technologies that

are available, affordable, transferable, and also make sense for the respective markets. Automation should be evaluated from a societal, environmental and ethical aspect.

Mr. Sundararajan said that Industry 4.0 is an opportunity for developing countries to leapfrog technology waves. While there is awareness among senior managers on what Industry 4.0 is, the question is how it can be used. This is where UNIDO can play an important role – in publishing case studies, best practices, and stories of successful implementation in developing countries. UNIDO can further collaborate on skills development and provide training for innovation management professionals and trainers.



QUESTIONS FROM THE AUDIENCE

What is your opinion of the impact of new technologies on the globalization of production and trade and global value and supply chains? What are the implications of insourcing and outsourcing for low- and high-end manufacturing and especially for developing countries and Least Developed countries (LDCs)?

Mr. Haddadin responded that the trend towards solution-based technology typically leads to specialized regions of technology, and due to connectivity there is a tendency to make these technologies global. Regarding production, because automation is becoming more affordable and more energy-efficient, it will be more local and more flexible. Some tasks will be automated that were not previously automatable. Some manual labour, currently outsourced from Europe, might come back. Due to the affordability of automation, it will be available to developing countries so that they can produce for their own markets. It will have tremendous effects on logistics value chains, but at the same time the products will be so complex that they have to be compatible and interact more intelligently.



What role does the environment play in a connected world? Product durability is a big issue nowadays. With urbanization and more people living in cities, will machines and robotics help us live more in harmony with nature?

Mr. Liu replied that for the new industrial revolution, one important issue was the IoT and cloud computing, which allows more customized products to be produced. This kind of individual customization will create new jobs and increase the share of manufacturing in GDP. When products are customized after service will also provide a lot of work opportunities.

On the question on the safe disposal of products, Mr. Sundararajan added that technologies like the IoT, which enable connected products, would help and that we would see a gradual shift to an after-service economy, so that the revenue of products continues to the end of the product; and even the disposal of the product can become a business. This will enable new business models and the revenue share of the after-market segment can increase. These technologies will eventually help in a circular economy to ensure that disposal of the product is environmentally-friendly.

At the beginning of the 19th century, the Luddites in the UK destroyed textile machines. In 2016, reports point to the risk of job losses due to automation. In terms of developing countries and economies in transition, how ready are we to face the economic and social challenges of Industry 4.0?

Ms. Hashim replied that some developing countries and economies in transition have embraced Industry 4.0, but not to the same extent as Research and Technology Organizations (RTOs) in advanced countries. Not many people know what Industry 4.0 is, and those that know about it also fear it. Perhaps if we try to explain it that fear will be reduced. Many people think that Industry 4.0 will happen tomorrow, but this is not the case. Like any technology, it will take some time.

CONCLUSION

If Industry 4.0 is to contribute to creating new wealth and further improve living standards, as the previous industrial revolutions did, we will have to:

- ▶ Highlight the benefits of Industry 4.0, for people, planet and prosperity
- ▶ Make major efforts to train and educate people
- ▶ Make technologies available and affordable so that they can be used in all countries
- ▶ Ensure digital inclusion
- ▶ Move from competition to connection and collaboration
- ▶ Take a customized approach to prepare for Industry 4.0
- ▶ Do not forget implementation
- ▶ Exploit the potential of Industry 4.0 to address climate change and conserve the environment





Franka Emika, a new generation of robots that builds itself, on display during UNIDO's 50th Anniversary Expo.



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