

UNIDO AND GMIS: PROMOTING STRATEGIC APPROACHES FOR THE FOURTH INDUSTRIAL REVOLUTION IN MEXICO

REPORT ON THE INDUSTRIAL
TRANSFORMATION MEXICO 2019
- HANNOVER MESSE EDITION



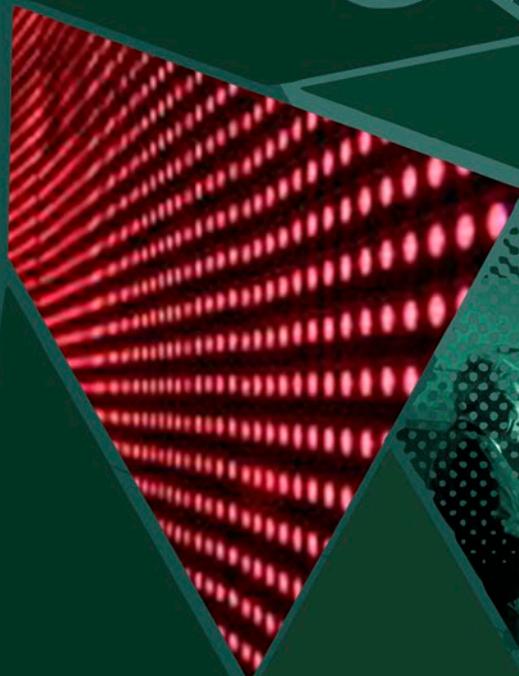
Industrial
Transformation
MEXICO



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

GMIS

Global Manufacturing &
Industrialisation Summit



**UNIDO AND GMIS: PROMOTING STRATEGIC
APPROACHES FOR THE FOURTH INDUSTRIAL
REVOLUTION IN MEXICO**

Report on the Industrial Transformation
Mexico 2019 - Hannover Messe Edition

**HANNOVER
MESSE**
a
event

**Industrial
Transformation**
MEXICO



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FOREWORD

The current Fourth Industrial Revolution (4IR, also referred to as Industry 4.0) describes a technology-driven paradigm shift that affects all aspects of life through the development of digital technologies (i.e. artificial intelligence -AI, the Internet of Things -IoT, machine learning, additive manufacturing, 3D printing, block-chain, inter alia) and their closer integration with biotechnology, nanotechnology and natural and social sciences (known as convergent and nature-like technologies).

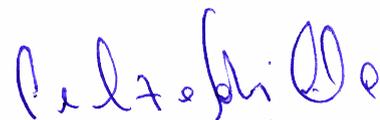
In combination, these new technologies can significantly contribute to advancing the 2030 Agenda for Sustainable Development, by leveraging Inclusive and Sustainable Industrial Development (ISID), which is the primary source of income generation; the vehicle for rapid and sustainable growth in living standards; and the foundation of an environmentally sound economic development.

The United Nations Industrial Development Organization's (UNIDO) approach to the Fourth Industrial Revolution targets four strategic areas, i.e. smart manufacturing, smart energy, smart agro-food and the circular economy. Within the sphere of action of each of them, UNIDO is engaging in knowledge sharing and capacity building, technical cooperation and the formulation of strategic partnerships with key stakeholders, including the private sector and academia.

Since 2015, UNIDO has participated in the Hannover Messe exhibitions, organizing several events, which promote Industry 4.0 awareness, facilitate identification and the assessment of risks brought by the exponential technological progress, and promotes partnership platforms to foster enterprises and investor collaborations.

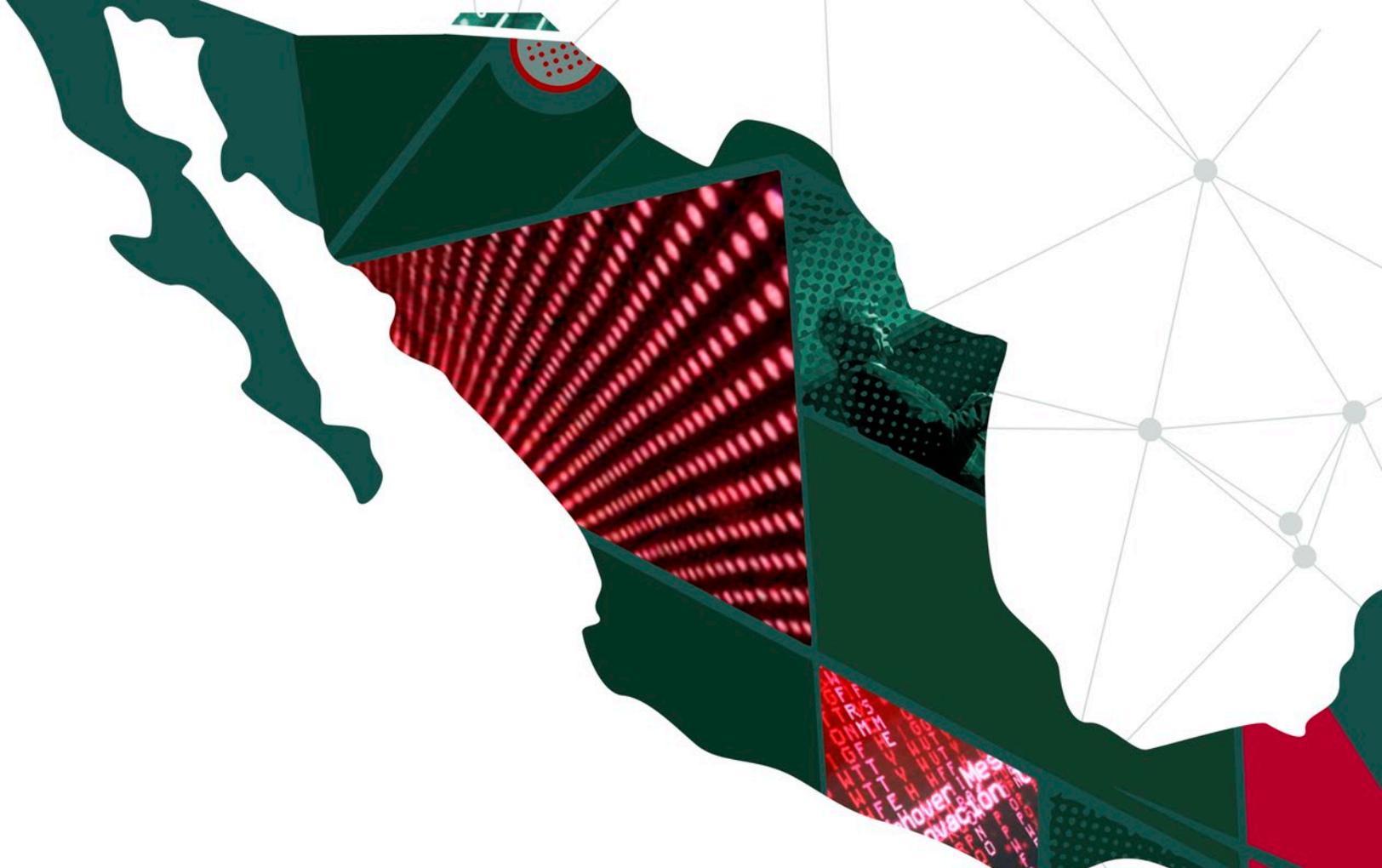
Within this framework, this report provides insights on how UNIDO and the Global Manufacturing and Industrialisation Summit (GMIS) are harnessing the trajectory of the 4IR for Inclusive and Sustainable Industrial Development (ISID) through multi-stakeholder dialogue, action and partnerships. It provides an analysis of best practices and strategic approaches for the circular economy, innovation and quality infrastructure to market access and integration of global value chains (GVCs) considering the industrial context of Mexico.

With the support of GMIS, Hannover Messe and all its partners and stakeholders, we firmly believe that UNIDO will substantially reinforce countries' readiness to ensure a smooth transition to the 4IR and take advantage of these opportunities for building prosperity, meeting the needs of people while protecting the planet.



Bernardo Calzadilla Sarmiento

Director of the Department of Trade, Investment and Innovation, UNIDO



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EXECUTIVE SUMMARY

The Industrial Transformation Mexico (ITM) 2019 is the first edition of Hannover Messe and leading Industry 4.0 event in Latin America and the Caribbean region. It served as a strategic platform where manufacturers, technology providers and opinion leaders exchange ideas, build new networks and capitalize on new technological solutions. Having gathered more than 30,000 participants, 175 speakers and 265 exhibitors, the ITM 2019 was in the words of Mr. Jochen Köckler, chairman of the Deutsche Messe, “a real benchmark hardly comparable with any other in the history of Deutsche Messe Group”.

Framed within the context of Mexico, one of the Latin American countries which has made the greatest progress in the transition to the Fourth Industrial Revolution (4IR), this report provides insights into the challenges, implications and opportunities of the 4IR (also referred to as Industry 4.0) for developing countries. It provides a general overview of Mexico’s industrial landscape by reviewing its national programmes and public policies; exploring their current rate of implementation across different sectors and examining the country’s specific challenges and opportunities in the face of the 4IR.

Considering the views and opinions exchanged during the panel discussions organized by UNIDO and GMIS during ITM 2019, this report emphasizes the key role of Inclusive and Sustainable Industrial Development (ISID) by leveraging the opportunities of the 4IR for advancing the 2030 Agenda for Sustainable Development. However, it acknowledges that this possibility will be contingent on strong cooperation ties and alliances between and among stakeholders including academic institutions, private business and governments.

In line with UNIDO’s strategic approach for assisting countries in their transformation to industry 4.0, the report explores best practices and strategic approaches to the circular economy (CE) and quality infrastructure (QI). It highlights that 4IR technologies and the application of the CE models can increase efficiency in the use of scarce resources and contributes to lessening negative environmental impacts. Similarly, QI is deemed crucial to both, fostering and adopting technological innovation and as a facilitator of the integration of SMEs into global value chains (GVCs).

The advent of the 4IR is driven by climate change concerns and confronted with elevated levels of inequality. At this critical juncture, countries should enforce appropriate mechanisms to safeguard the environment, ensuring that the vast array of potential benefits brought by the 4IR are evenly distributed among all society members, assigning a higher priority to the disadvantaged groups currently affected by structural discrimination such as women, people with disabilities, indigenous people and ethnic minorities.

A smooth transition to the 4IR will require the adoption of inclusive strategies in which all actors have their interests adequately represented; embracing a systemic approach and far-reaching strategies informed by the rapidly changing trends; incentivizing local innovation and creativity; encouraging new forms of collaborations with all stakeholders, and promoting participatory forums such as the ITM 2019 for sharing knowledge and ideas for accelerating technology adoption, attracting investment and encouraging industrial cooperation.

LIST OF ABBREVIATIONS

Fourth Industrial Revolution	4IR
China Federation of Industrial Economics	CFIE
Economic Commission for Latin America and the Caribbean	ECLAC
General Data Protection Regulation	GDPR
Global Manufacturing & Industrialisation Summit	GMIS
Global Value Chains	GVCs
Gross Domestic Product	GDP
High Quality	HQ
Inclusive and Sustainable Industrial Development	ISID
Industrial Innovation Centres	IIC
Industrial Transformation Mexico	ITM
Industry 4.0	I4.0
Information and Communication Technologies	ICT
Internet of things	IoT
Investment and Technology Promotion Offices	ITPOs
Latin America and the Caribbean	LAC
Least Developed Countries	LDCs
Machine-to-Machine	M2M
Memorandum of Understanding	MoU
Mexican Association of Industrial Parks	AMPIP
National Standards Body	NSB
Non-Governmental Organization	NGO
National Council of Science and Technology	CONACYT
National Institute of Statistics and Geography	INEGI
Science, Technology, Engineering, and Mathematics	STEM
Testing, Inspection and Conformity	TIC
Ministry of Communication and Transport	SCT
Ministry of Economy	SE
Multi-National Corporations	MNCs
Spanish Confederation of Business Organizations	CEOE
Sustainable Development Goals	SDGs
United Nations Industrial Development Organization	UNIDO
World Economic Forum	WEF

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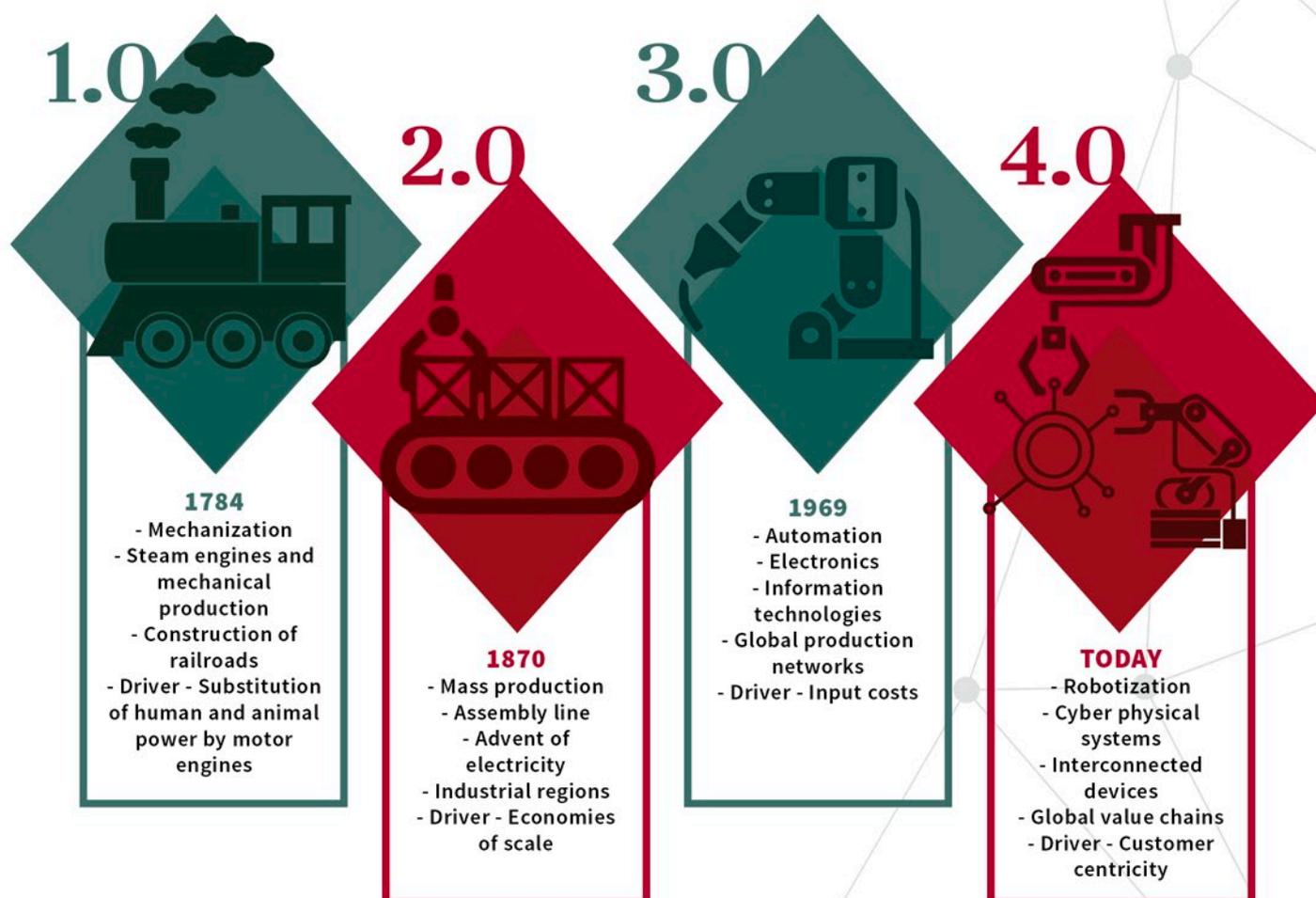
INTRODUCTION

Following the successful participation of Mexico as a guest country in Hannover Messe 2018, Deutsche Messe AG decided to hold the first edition of its leading global fair in Mexico, thus creating Industrial Transformation Mexico (ITM), the first edition of which took place in Leon, Guanajuato, from 9 to 11 October 2019.

Industrial Transformation hinges upon revolutionary ways of operating business that are evolving due to exponential technological shifts. Each industrial revolution is characterized by a set of technological innovations that redefine how we live, work, move and interact. Figure 1 shows the characteristics of each industrial revolution articulating the transitions in industrial developments. This explains the reasoning behind ITM 2019, that is, raising awareness about the importance, significance, opportunities and implications of the 4IR (also referred to as Industry 4.0) in driving industrial transformation in Mexico.

Each industrial revolution is characterized by a set of technological innovations that redefine how we live, work, move and interact.

Figure 1 The Four Industrial Revolutions



Source: Author's own compilation based on *The Geography of Transport Systems*¹

ITM 2019 consisted of a tradeshow, conferences and educational programmes tied together by the overarching themes of smart manufacturing and digital transformation in Mexico. The event was significant to all industrial sectors. In addition, stakeholders from several sectors recognized that the ITM 2019 has positioned itself as the leading event to promote digital transformation and intelligent manufacturing both in Mexico and Latin America. The main themes promoted during the first edition were automation, robotics, digital manufacturing, ICT and intelligent logistics, among others.

ITM 2019 also served as a framework for the Annual Industrialists Meeting (RAI) organized by the CONCAMIN (Mexican Industrial Chamber Confederation). UNIDO has a successful partnership with Deutsche Messe AG and CONCAMIN; as the main ITM organizers, they approached UNIDO and the Global Manufacturing and Industrialisation Summit (GMIS) managers to join efforts and reinforce the educational role of the fair.

This report gives a background of the prevailing industrial position of Mexico and the country's efforts towards industrial transformation with a specific emphasis on industry 4.0 concepts. It discusses the outcomes and impact of the ITM and highlights the cooperation between UNIDO and GMIS as event organizers. It examines UNIDO's strategic approach for accelerating Inclusive and Sustainable Industrial Development (ISID) and supporting developing countries to improve the adoption rate of emerging technologies.

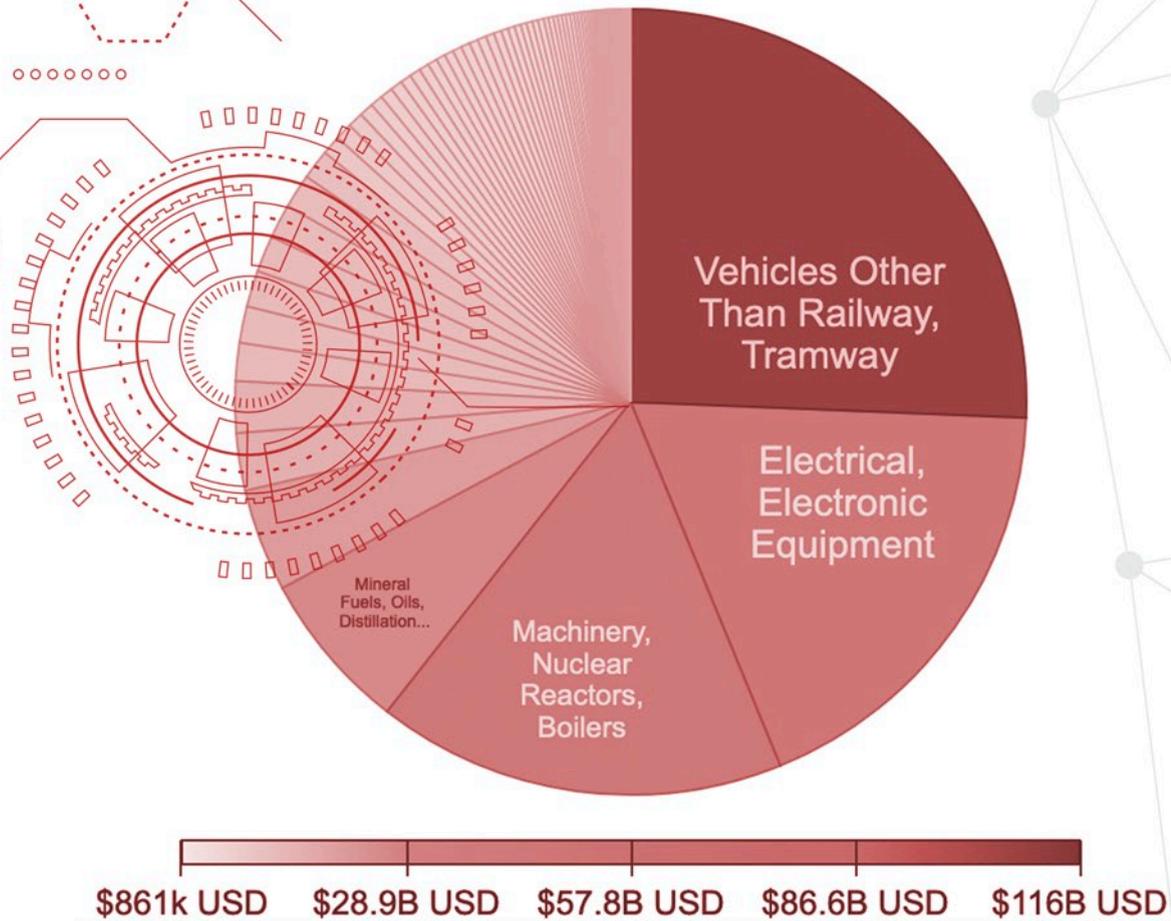
ITM 2019 has positioned itself as the leading event to promote digital transformation and intelligent manufacturing both in Mexico and Latin America.

CHAPTER 1. MEXICO AND THE FOURTH INDUSTRIAL REVOLUTION

1.1 General Context of Mexico

In the 1970s, international trade represented around 17% of Mexico's Gross Domestic Product (GDP) and by 2018, the contribution of trade to the GDP had reached 80%². Since the 1970s, Mexico has consolidated itself as an export-oriented economy. Over the past ten years, Mexico climbed three positions to become the world's fourteenth leading trader of goods and services. Regarding manufactured goods, Mexico is the world's seventh largest exporter, among which vehicles and electronic equipment are accountable for around 26% and 18% of total national exports, respectively (Figure 2)^{3,4}.

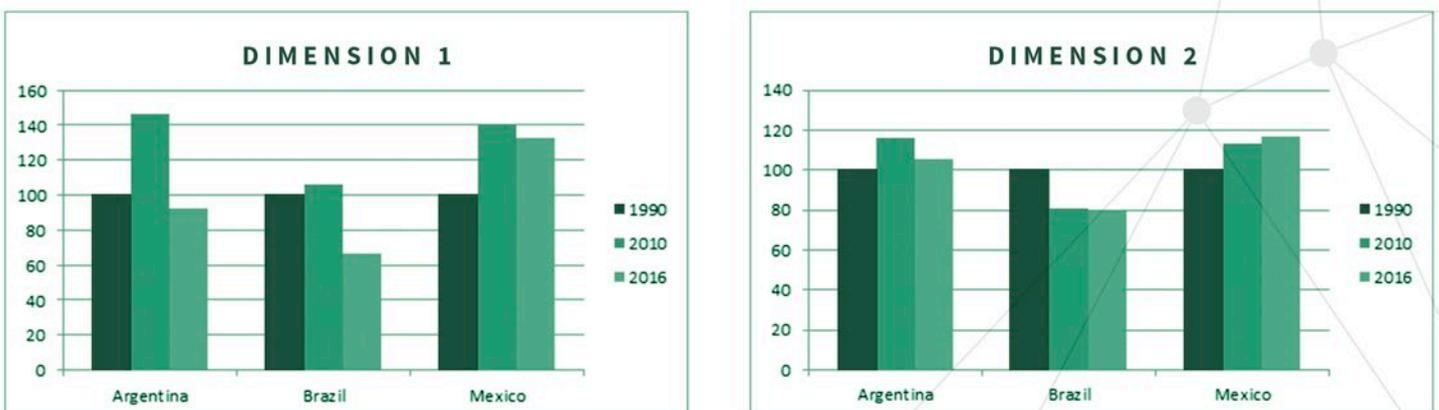
Figure 2 Mexico Exports by Category

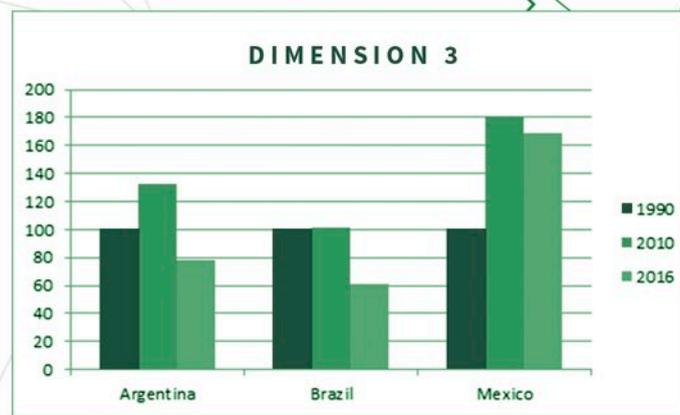


Source: United Nations COMTRADE database on international trade (2018).

According to the Competitive Industrial Performance Index (CIP) 2019, the country is located in the first quintile, occupying the 22nd position of 150 countries analysed. Within the regional context, the country ranks first, with a clear advantage over neighbouring countries in the technological deepening, upgrading and world impact dimensions (Figure 2).

Figure 3 Performance in the three CIP dimensions, Argentina, Brazil and Mexico, 1990-2016





Source: *Competitive Industrial Performance Index 2018*⁵. Note Dimension 1: Capacity to produce and export; Dimension 2: Technological deepening and upgrading; Dimension 3: World impact.

Mexico has signed twelve Free Trade Agreements that facilitate access to markets in at least 46 countries. As an exporting powerhouse, it is essential to enhance the country's capabilities, in order to leverage the potential benefits stemming from the 4IR. Since 2015, the Government of Mexico has launched a series of initiatives and programmes which are aimed at raising awareness among small and medium-sized enterprises (SMEs) on the importance of Industry 4.0 and to support the adoption of Information and Communications Technologies (ICTs) and wider digitalization efforts⁶. The Mexican Government promotes laws that set an important precedent for the regulation of new technologies⁷ and outlined a national strategy to lead the country on the path to the 4IR⁸. Nonetheless, further efforts are needed to improve the ICT infrastructure and ensure connectivity for both companies and citizens; foster national innovation capabilities to embrace, adapt and reinvent technologies for enhancing its international competitiveness.

1.1 Mexico's Role in the 4IR

Mexico is one of the Latin American countries which has made the greatest progress in the transition to the 4IR. According to The Global Competitiveness Report 2019, Mexico is ranked 48th among the world's most competitive economies and is placed second in Latin America. The most significant developments have been made in ICTs adoption, the labour market and in production.

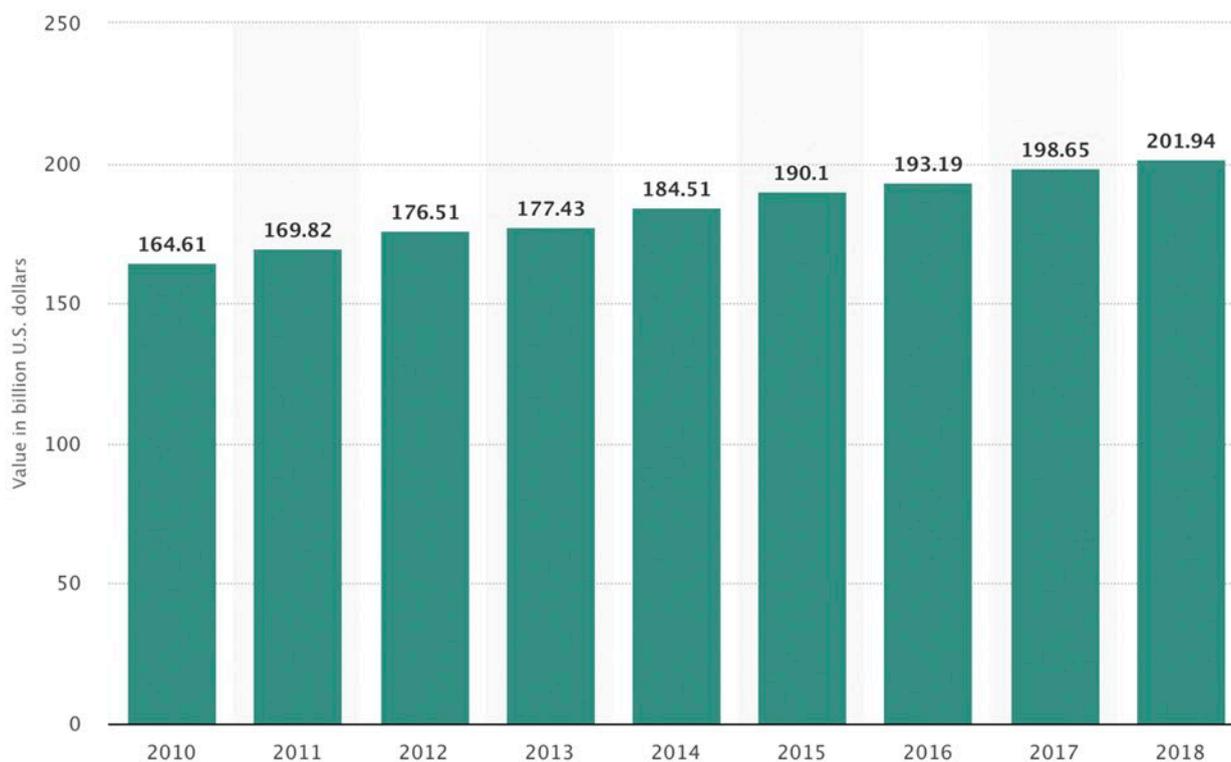
However, progress remains insufficient to achieve the competitive economy essential to accelerate the country's industrial transformation⁹. Security, macroeconomic stability and infrastructure require further actions to systematically strengthen Mexico for the 4IR.

The manufacturing sector employed in 2018 around 25% of the Mexican workforce¹⁰. In 2019 it was accountable for adding almost 202 billion dollars to the country's GDP (Figure 4)¹¹. According to the National Chamber of Industrial Transformation, the number of research laboratories experienced a sustained increase, growing from 11 units in 2013 to 72 in 2018. Around 110,000 technology and engineering students graduate every year. However, there are also some asymmetries and imbalances among Mexico's most competitive sectors. Although electro domestics, food processing and the textile sectors have the highest levels of competitiveness, the automotive and aerospace industries are accountable for the application of the most advanced technologies¹². Large multi-national corporations (MNCs) are responsible for a significant amount of the total investment in new technologies.

In contrast, several Mexican companies are still locked into the first and second generation of production models. Thus, MNCs are more competitive, productive and better equipped for a digital transformation¹³. Table 1 gives an overview of the industrial sectors where Mexico has greater participation than the global average, and shows its current progress in the transition to 4IR.

Several Mexican companies are still locked into the first and second generation of production models.

Figure 4 Value added to gross domestic product by the manufacturing sector in Mexico 2010- 2018



Source: Mexico: manufacturing sector's added value to real GDP 2010-2018
<https://www.statista.com/statistics/1075745/manufacturing-industry-added-value-gdp-mexico/>

Table 1 Overview of Mexico's Competitive Industrial Sectors and their Transition Progress Towards the 4IR

SECTOR	Data of Interest and Advances for the 4IR	4IR Transition Level and Strategy
AUTOMOTIVE	<ul style="list-style-type: none"> - The second largest contributor to the national GDP (2% GDP and 18.3% of the manufacturing sector). - The most advanced sector in the design of technological strategies and adoption of new technologies. - Seventh-largest manufacturer of vehicles and the fifth largest manufacturer of auto parts in the world. 	<ul style="list-style-type: none"> -Medium-high transition level -Medium knowledge and awareness of Industry 4.0 technologies -Moderate progress in the adoption of 4IR technologies -A defined long-term strategy of digital transformation (2018-2024) based on four pillars: 1) Fostering growth and modernization of the internal market; 2) Improving microeconomic conditions for doing business; 3) Continuing working on foreign trade agreements; 4) Improving innovation, increasing investment in Research and Development¹⁴.
ELECTRO-DOMESTICS	<ul style="list-style-type: none"> - The fifth largest exporter of household appliances in the world. - First place worldwide as an exporter of refrigerators and freezers with separate doors¹⁵. - Main exporter in Latin America. - Very low level of local production. - It represented 0.12% of the national GDP and 1.5% of the manufacturing sector in 2012¹⁶. 	<ul style="list-style-type: none"> -Low transition level -Basic knowledge and awareness of Industry 4.0 technologies. -Incipient implementation of sectoral strategies.
FOOD PROCESSING	<ul style="list-style-type: none"> - Ranked the 10th worldwide food processors. - 72% food oriented towards the USA market. 	<ul style="list-style-type: none"> -Medium transition level -Moderate knowledge and awareness of Industry 4.0 technologies. -Large companies leading implementation. - Subsidiaries of foreign and Latin MNCs have a digital transformation strategy, focused on the integration of suppliers and distributors, while SMEs are still lagging behind.
TEXTILE	<ul style="list-style-type: none"> - Accountable for the most advanced 4.0 supply chain in Latin America, due to the economic importance of maquiladoras. 	<ul style="list-style-type: none"> -Low transition level -Incipient knowledge, awareness and implementation progress . - Special programme to strengthen the textile industry. The objective was to protect local industry against counterfeit products from Asia and increase access to financing for SMEs.

Source: Author's own compilation based on "Supply Chain 4.0"¹²

UNIDO's Industrial Development Report 2020¹⁷, launched at the Organization's 18th Annual General Conference in Abu Dhabi identifies a framework of analysis linking new technologies with ISID. It asserts that the creation and diffusion of advanced digital production (ADP) technologies is highly concentrated in a group of 10 economies, "the frontrunners"— which are accountable for 90% of the related patents registered globally and around 70% of technology exports. The "followers in production" (23 economies) are economies actively involved in patenting in the field of ADP technologies. "Followers in use" (17 economies) are economies actively involved in importing ADP-related goods and relatively specialized in importing ADP-related goods that purchase large volumes in world markets (Figure 5).

Figure 5 Countries and Economies by Level of Engagement with ADP Technologies Applied to Manufacturing

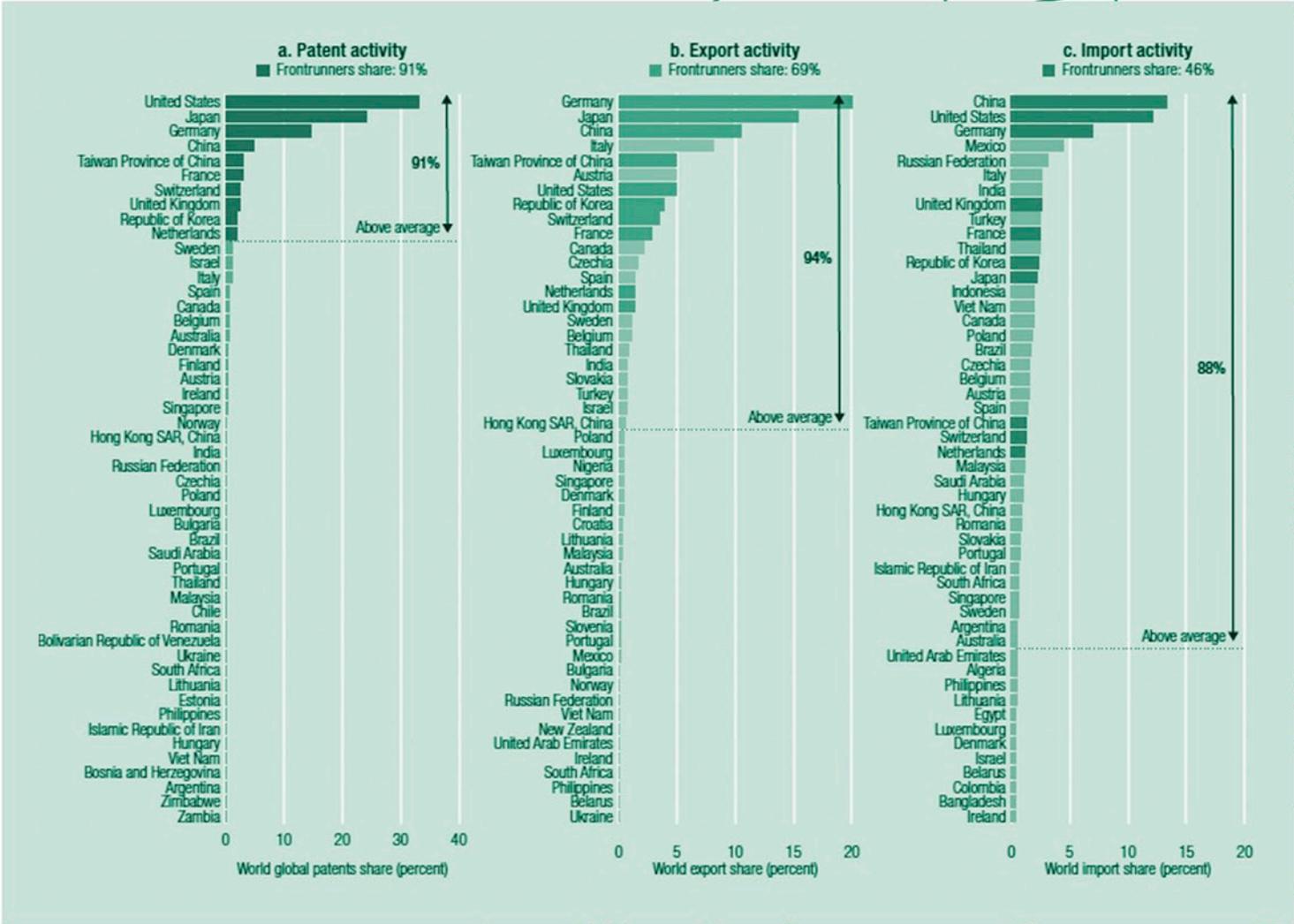
Table A1.2
Countries and economies by level of engagement with ADP technologies applied to manufacturing

Frontrunners (10 economies)	Followers (40 economies)		Latecomers (29 economies)		
	As producers (23 economies)	As users (17 economies)	As producers (16 economies)	As users (13 economies)	Laggards (88 economies)
<i>Economies actively engaging with ADP technologies</i>					
China	Australia	Algeria	Bosnia and Herzegovina	Costa Rica	All other economies that, according to the United Nations Statistical Division, had more than 500,000 inhabitants in 2017
France	Austria	Argentina	Bulgaria	Côte d'Ivoire	
Germany	Belgium	Bangladesh	Chile	Ecuador	
Japan	Brazil	Belarus	Dominican Rep.	Egypt	
Korea (Republic of)	Canada	Colombia	Estonia	El Salvador	
Netherlands	Croatia	Hungary	Greece	Ethiopia	
Switzerland	Czechia	Indonesia	Kyrgyzstan	Malawi	
Taiwan Province of China	Denmark	Iran (Islamic Republic of)	Latvia	Serbia	
United Kingdom	Finland	Malaysia	Moldova (Republic of)	Tunisia	
United States	Hong Kong SAR, China	Mexico	New Zealand	Turkmenistan	
	India	Portugal	Nigeria	Uganda	
	Ireland	Romania	Philippines	Uzbekistan	
	Israel	Saudi Arabia	Slovenia	Zambia	
	Italy	South Africa	Slovenia		
	Lithuania	Thailand	Ukraine		
	Luxembourg	Turkey	United Arab Emirates		
	Norway	Viet Nam	Venezuela (Bolivarian Republic of)		
	Poland				
	Russian Federation				
	Singapore				
	Slovakia				
	Spain				
	Sweden				

Source: Industrial Development Report 2020, UNIDO.

According to the report, Mexico is among "the followers in use" due to the high level of ADP-related import and comparatively lower patent applications. In fact, Mexico is among the first five higher volume technology importers (Figure 6). According to the Mexican Association of Machinery Distributors, the approximate value of machinery imports (up to October 2019) reached 1,500 million US dollars. In 2020, this figure is expected to grow between 2 and 3%¹⁸.

Figure 6 Patenting, Exporting and Importing of ADP Technologies



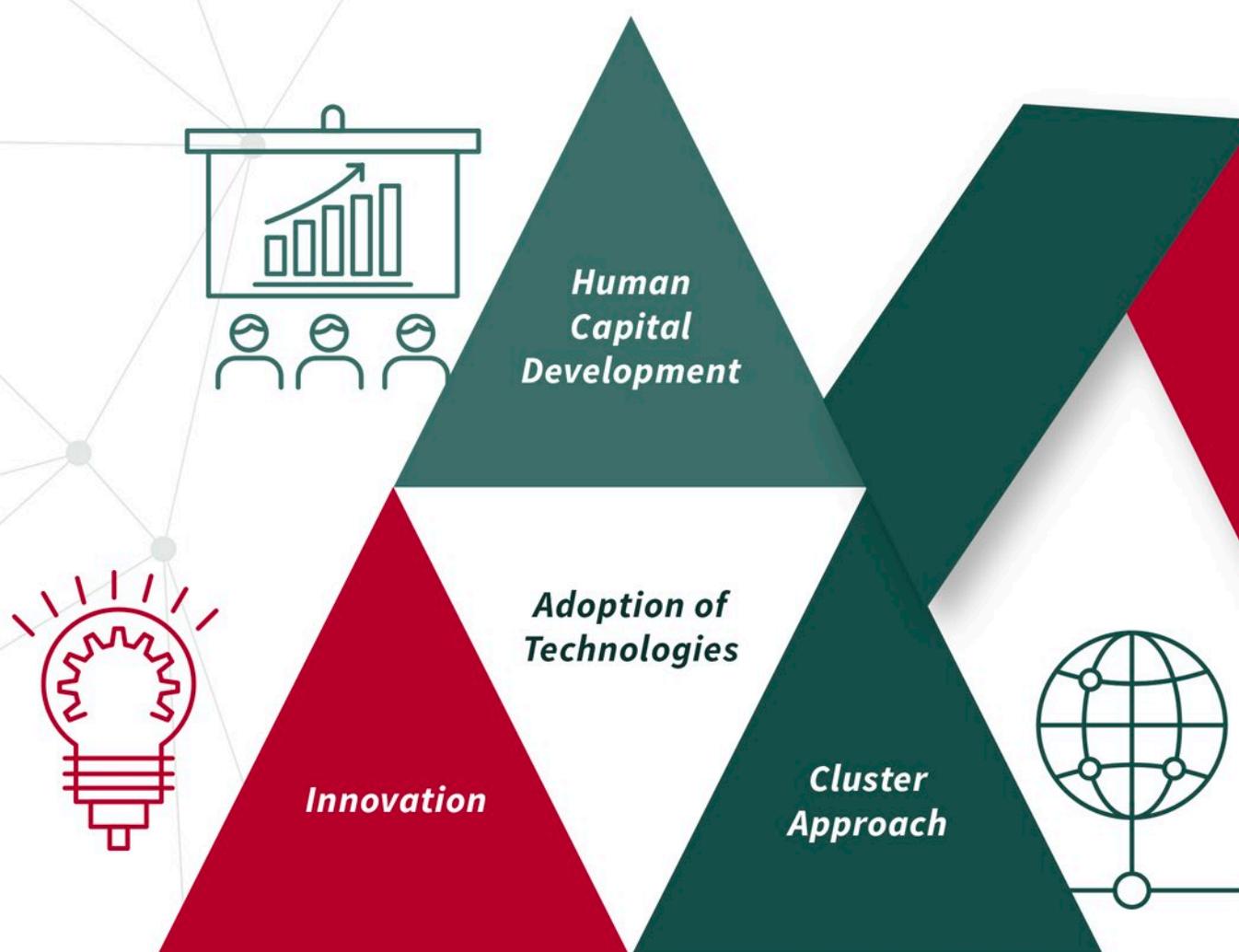
Source: Industrial Development Report 2020, UNIDO.

1.2 National programmes and initiatives for Mexico's transition to the 4IR

The formulation of policies and programmes aimed to move the country towards the 4IR take into account four fundamental pillars related to productivity and competitiveness¹⁹. They are as follows (Figure 7):

- ° **Human capital development.** Skills in data mining analytics, information processing and cybersecurity, among others.
- ° **Innovation.** Specific tools that enable companies to design new products and business process.
- ° **Cluster.** Positive synergies between the clusters to trigger coordinated actions.
- ° **Adoption of technologies.** More productive and competitive processes in medium and small companies.

Figure 7 Four Pillars of Productivity and Competitiveness



Source: Secretaría de Economía 2018. *El desarrollo de la Industria 4.0 en México*.
<https://www.gob.mx/se/articulos/el-desarrollo-de-la-industria-4-0-en-mexico?idiom=es;>

As a result of government efforts to ensure a smooth transformation of the country, a number of strategic alliances, programmes and initiatives have been developed, including:

1. Crafting the future: A roadmap for Industry 4.0 in Mexico. This is an approach to the national value-added strategy for the manufacturing industry. The policy analyzes the characteristics of the manufacturing sector in comparison to strategies around the world, as well as the momentous manufacturing trends within the 4IR. Concurrently, it reinforces the strategic positioning of the sector with an emphasis on new technologies, education and digital economies.

2. Programme for the Development of the Software Industry (PROSOFT). The programme was introduced by the “Secretaría de Economía” (SE) to foster economic innovation through the creation and strengthening of Industrial Innovation Centres (IICs) and public policies which promote the development of innovation ecosystems. The policy plays a fundamental role in capitalizing on opportunities brought forth by the 4IR, through the adoption of emerging technologies, specialization of human resources, knowledge transfer and promotion of initiatives accelerating productivity growth in Mexico²⁰.

3. Industrial Innovation Centers (IIC). These are semi-public spaces, based on the investment of public and private resources, with the objective of training, specialization and certification of human capital and the provision of specialized services. IICs can be arranged in two modalities: individual or consortium.

4. Mexico 4.0 Alliance. A support programme for the development of digitization projects for the business sector⁶.

5. Productivity and Innovation Center for Industry 4.0 (CEPRODI 4.0). A programme for the 4IR that offers consultancy services to companies including demonstration projects to aid the adoption of Industry 4.0 technologies. FUMEC Initiative (United States-Mexico Foundation for Science).

6. Public research centers (CPI) that integrate the infrastructure of the National System of Science, Technology and Innovation (SNCTI). This is coordinated by the National Council for Science and Technology (CONACYT). The CPIs are research, training and knowledge transfer institutions with a close link to enterprises and productive groupings located in different states of Mexico. This policy has become the driving force in training of high-level human resources with multidisciplinary content, generating 75% of the scientific, technological and human capital training activity outside Mexico City, with a presence in 28 states and 61 cities in the country²¹.

7. Technological Innovation Fund (FIT) Managed by CONACYT and SE, FIT support projects for the improvement of products, processes and services; the creation and consolidation of research groups associated with the industry, and the pre-commercial validation of the scientific-technological content of projects in the SME segment²².

8. Advanced Manufacturing Technology Centre (MTAC). Aims to assist companies to achieve high levels of productivity and cost-efficiency through technologies and processes such as big data, cloud computing, automation, IoT and process integration. Primarily aimed at three industrial sectors, that is, automotive, mining, and food and beverage²³.

9. Intersecretarial Commission for the Development of Electronic Government (CIDGE). This is an organization whose purpose is to create the Inter-Ministerial Commission for the Development of Electronic Government. Its objective is to promote and consolidate the use and exploitation of ICTs in the Federal Public Administration²⁴.

10. Decalogue of Industrial Policy of Mexico. Mexico's new industrial policy broadly includes the following Decalogue: 1) promote greater economic competitiveness, 2) expand the country's productive capacities through trade liberalization, 3) reduce regulatory costs and facilitate compliance with the three government orders, 4) attract greater domestic and foreign investment flows, 5) encourage the growth of SMEs and domestic content for the production of goods and services, 6) encourage the digitization of the manufacturing sector and promote I4.0, 7) modernize standardization processes and promote quality infrastructure, 8) increase productivity and competitiveness through a healthy economy, 9) increase financing from development banks for industrial projects, and 10) encourage industrial projects in the lagging regions of the country²⁵.

11. Programme for Industrial Productivity and Competitiveness (PPCI). Its objective is to improve the productivity of enterprises by supporting industrial projects and initiatives that promote inclusive economic growth. It is an instrument aimed at promoting an increase in the productivity of medium and large enterprises, contributing to the strengthening and development of the sector through the design of methodologies for the differentiation of products, the design and implementation of sector promotion strategies and the equipment of production enhancement centers, test laboratories and specialized machinery and equipment for enterprises; contributing to the development and articulation of value chains in sectors and industries²⁶.

1.3 Mexico's Challenges and Opportunities in Reaching the 4IR

The 4IR has a worldwide impact on the design and implementation of commercial operations. Therefore, it is important to consider the particular conditions in which Mexico is facing the adoption of new technologies and business models as well as leveraging potential opportunities to accelerate its industrial transformation. Considering the particular context of Mexico, a number of potential challenges and opportunities are listed below.

Challenges

- Establish adequate mechanisms to ensure the development, implementation and continuous assessment of far-reaching 4IR transformation strategies, highly resilient to electoral cycles.
- Systematically increase collaboration and cooperation ties between academia, the public and private sectors.
- Establish an integrated and consistent approach to design and execute automation and digitalization measures within the public sector.
- Overcome current infrastructure constraints affecting connectivity, digital integration, communication and transport across country regions.
- Counteract low digitalization and technological adoption levels among logistics service providers.
- Address the existent imbalance between the costs of labour and automation costs that continues undermining technological adoption. Presently, the low cost of labour is comparatively cheaper than the investment required for adopting new technologies, especially among SMEs.
- Strengthen the institutional capacity to support human capital formation across industrial sectors and to develop regulatory frameworks that meet the rapidly changing business environment.
- Overcome QI shortcomings to heighten national innovation capabilities, enable the adoption of new technologies and facilitate market access.

Opportunities

- The operations of a high number of manufacturing plants in the automotive, aerospace and electronics industries are already in line with international best practices and could be emulated and adopted by other industrial sectors⁶.
- About 19% of automotive sector companies are digital leaders²⁷. Their further integration into clusters could lead the assimilation and modernization of a greater number of Mexican companies.
- Promote closer collaboration between academic institutions, the public and the private sectors, to support the development of new specialized areas of knowledge among different industrial sectors.
- Enhance local innovation capabilities by fostering partnerships with leading international academic institutions, facilitating academic exchanges and upgrading the installed capacity of national research institutions.
- The government has implemented programmes for the digitalization of public services. 4IR technologies can further enhance their impact and efficiency and reduce the cost of developing new ones for the benefit of citizens.
- Mexico is implementing the 2030 Agenda for Sustainable Development as part of its National Development Plan. In combination with other strategies, this could make a significant contribution to the country's transformation.
- Leverage from forums and platforms, such as the ITM 2019, for raising awareness among the national industrial sector and promoting strategic alliances to accelerate the adoption of digital technologies.

The above discussed points can be exemplified within the context of the automotive sector. For example, a greater adoption of 4IR technologies among Mexican automotive sector companies in combination with an improved capacity of existing QI systems, could lead to a significant increase in the productivity and competitiveness of local Mexican automotive suppliers. In turn, this improvement could lead towards meeting the requirements of the large number of OEMs and Tier-1 manufacturers operating in the country. Thus, promoting a greater integration of local automotive suppliers into GVCs. A potential intervention could be guided by some of the following actions:

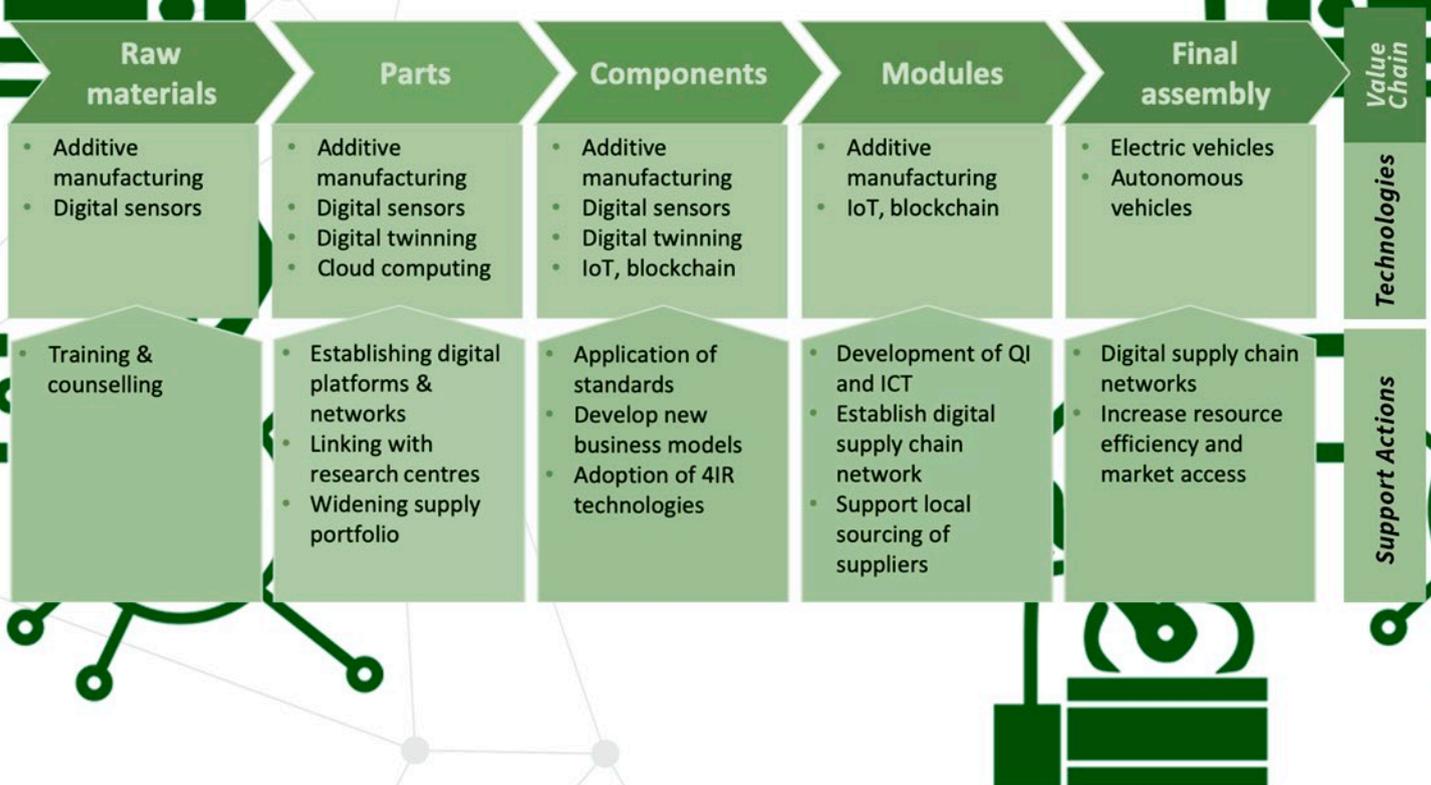
- Providing technical assistance to OEMs and Tier-1 manufacturers as well as local support entities (cluster bodies, chambers, etc.) to have access to adequate databases of relevant local firms and their production capacities for networking and collaborations.
- Facilitating cluster formulation and enhance cluster bodies' service portfolios to lower tier suppliers in line with international best practice models for easy expansion of GVCs.
- Fostering networking partnerships between and among local component/inputs/materials manufacturers and developing linkages with vehicle manufacturers and Tier-1 suppliers and enhance their investment attractiveness for local-foreign joint ventures or technology partnerships.
- Helping local (existing and potential future) vehicle component suppliers to improve their compliance levels regarding relevant standards, technical regulations and OEM requirements, and improve their productivity.
- Supporting local suppliers to adopt or upgrade 4IR digital technologies and strengthening ties with research centres for developing and improving current products and processes.

Concerning the actions intended to promote the adoption or upgrading of 4IR technologies, these could include the following:

- Assessing the readiness for adoption of 4IR technologies and preparing individualized action plans to enable a smooth 4IR digital transformation
- Analysing the existing capacities of academic institutions for the establishment of a local learning/ training centre in Industry 4.0 technologies and business models;
- Fostering the establishment of digital networking/platforms; and developing a 4IR sectoral strategy, stressing the needs of the Tier 2 and Tier 3 levels, oriented to inform future public policies and programmes.

Figure 8 shows a graphic representation of a potential intervention to support the adoption of 4IR technologies at each stage of the value chain within the specific context of the automotive sector.

Figure 8 A Staged Application of Industry 4.0 Technologies on the Automotive Value Chain



Source: Author's compilation based on Noealt, 2005-2019, Strategic perspective Decisive Age²⁸

Some key developments of 4IR technologies impacting the automotive value chain can be further explained below:

- The combination of **IoT** and **cloud computing** can enable near-real-time collaboration between suppliers, OEMs and customers. The integration of machine learning and robotics can increase the efficiency and accuracy of monotonous and repetitive tasks. DLT (*i.e. blockchain*) and IoT devices can facilitate collaboration and automate time-consuming processes between all participants of the supply chain. Additive manufacturing can allow for in-house and faster development of components and parts with serious implications for suppliers. *Artificial Intelligence* and IoT are furnishing supply chains with higher level of automation and response capacity to react to unexpected events without significant manual effort.

- **Digital twinning** is being increasingly used for assisting each of the stages of the *product life cycle*. It allows a virtual model or representation of a system such as product design, process or a factory that can be used to understand performance better, improve processes or create revenue opportunities from services. The key building blocks for *digital twinning* are connectivity and networks, data intelligence, simulation and human –machine interfaces.

- Incorporated into the new generation of vehicles, **sensors** are embedded into various objects and systems to collect data in real-time. These data points are collected from radars, engines, cameras and more to regulate the operation of vehicles. In the following years, these *sensors* will become more intelligent up to the point where they are capable of pre-processing and filtering data thus generating an immense impact on security, safety, and the cost of vehicle maintenance. The successful connectivity series of digital visual devices in vehicles is embedded at early stages of components production. Suppliers ought to be first movers for sustenance, notwithstanding the impact of globalization on usual business demands.

- **Additive manufacturing** can make a significant contribution to automotive supply chains by reshaping the prototyping process. New models can now be more easily created, tested and improved. This technology also facilitates moving towards greater levels of customization thanks to the possibility to produce custom, complex and high-performance parts. Moreover, the rising affordability of this technology will allow a greater number of companies to integrate it as an in-house solution to support processes on the factory floor.

The 4IR is leading a fundamental shift in the business model of every automotive company and supplier today. OEMs, for example, are evolving from a linear supply chain to a networked and tightly interconnected supply chain — and from a relatively straightforward production line to a complex ecosystem of actors. The rising capabilities of the 4IR technologies are advancing the consolidation of these new models and turning them into common industry practices.

CHAPTER 2. UNIDO, GMIS AND THE FOURTH INDUSTRIAL REVOLUTION

2.1. Inclusive and Sustainable Industrial Development

The Global Manufacturing and Industrialisation Summit (GMIS) is a 4IR platform that builds communication bridges between manufacturers, governments, NGOs, technologists, and investors to regenerate the global economy through harnessing the 4IR opportunities. Hence, GMIS is a platform that presents the manufacturing sector with an opportunity to contribute towards global good, working to the benefit of all²⁹.

GMIS was established in 2015, with the Co-Chairs of the initiative being the United Nations Industrial Development Organization (UNIDO) and the Ministry of Energy and Industry of the United Arab Emirates. GMIS aims to accomplish effective collaboration through knowledge management. GMIS is committed to enhancing economic growth policies with manufacturing at the core for the sector's substantial capabilities in revenue generation, jobs creation and crucial role in global prosperity.

UNIDO has a pivotal role in promoting of the 4IR to achieve ISID and the UN's 17 interconnected and complementary Sustainable Development Goals (SDGs). UNIDO strives to accomplish this mandate by promoting the development of new norms and standards, conducting research that supports policy advice, building knowledge sharing platforms and developing the appropriate technical cooperation for the UNIDO Member States²¹.

The Abu Dhabi Declaration was adopted at the eighteenth session of the UNIDO General Conference in 2019. It emphasizes the important role of the private sector in advancing the 2030 Sustainable Development Agenda. According to the Director General of UNIDO, LI Yong, "the private sector draws attention to the emergence of frontier technologies of the 4IR with the disruptive potential which more importantly, offers tremendous opportunities to advance economic growth, human well-being, and safeguard the environment."

The Abu Dhabi Declaration builds on the Organization's mandate to advance ISID around the world, a mandate set out in the Lima Declaration adopted at the 15th session of the UNIDO General Conference, held in Peru in 2013¹⁷. This was a critical shift from the era of the Millennium Development Goals and serves as a foundation for the development of SDG 9, which recognizes that industry and industrialization are the main drivers of sustainable economic growth, environmental sustainability and shared prosperity³⁰.

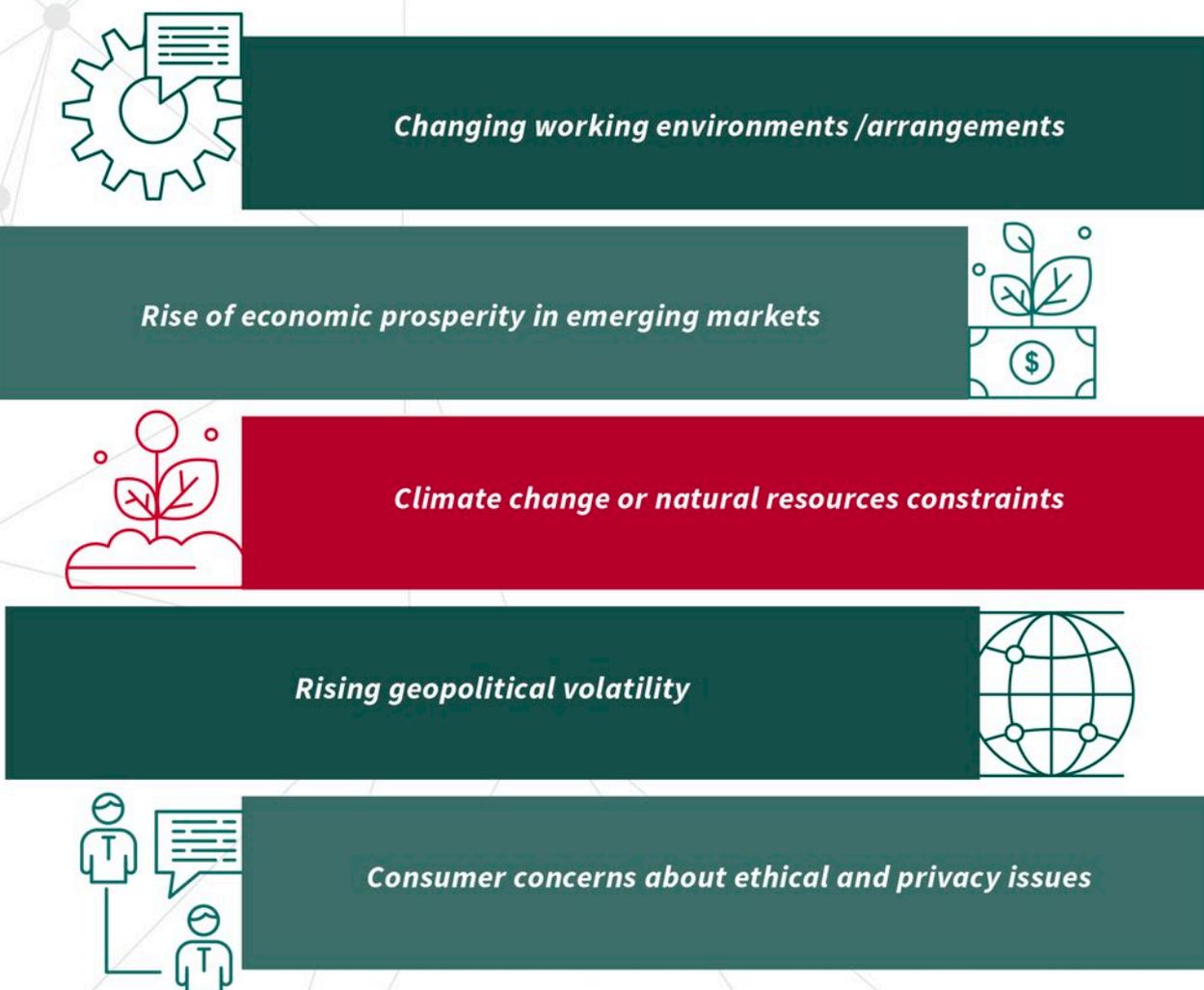
The cooperation between UNIDO and GMIS is significant since it combines the best of GMIS through the centralization of information, leaders of different economic sectors, government agencies and academic institutions of the manufacturing sector with the mandate of UNIDO, that is, to achieve Inclusive and Sustainable Industrial Development (ISID) through innovation and quality infrastructure within the manufacturing sector and identification and implementation of the SDGs, specifically SDG9 in different industrial contexts of the 4IR, creating better economic opportunities, safeguarding the environment while also being socially responsible.

2.2 Drivers, Challenges and Opportunities of the Fourth Industrial Revolution

The Fourth Industrial Revolution (4IR) promises a world in which virtual and physical systems of global manufacturing cooperate with each other in a flexible way. This enables absolute customization of products and the emergence of new business models. The 4IR is not only about smart and interconnected machines and systems, but also a fusion and interaction across physical, digital and biological domains, in areas from gene sequencing to nanotechnologies, from renewables to quantum computing; that makes the 4IR fundamentally different from the other revolutions in history³¹.

The major technological advancements of the 4IR are revolutionizing industrial production. 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. This transformation could be defined by three characteristics: velocity, scope and systems impact. The breadth and depth of changes in industry and technology have driven the transformation of entire systems of production, management, and governance³².

Figure 9 Drivers of the 4IR



Source: *The challenge Insight Report, The Future of Jobs, Employments, Skills and workforce strategy for the Fourth Industrial Revolution: World Economic Forum, January 2016*³³

Challenges of the Fourth Industrial Revolution

The challenges created by the 4IR appear to be production driven. Technology applications and strategies are anticipated to create more job opportunities and improve the quality of life. One of the challenges for the 4IR is that the response to it must be integrated and comprehensive, involving all stakeholders of the global policy, from the public and private sectors to academic and civil society³¹.

At the same time, globalization launched by the Third Industrial Revolution has enabled notorious income and wealth inequality. The 4IR operates under old rules of ownership and moves into open spaces in the current system. It creates new jobs and sets new labour rules, but at the same time, it also contributes to eliminating outdated professional activities.

Operating on a worldwide basis, it is clear that the 4IR distributes rewards and benefits on a global scale, rather than locally or nationally. It can thus help to concentrate power and resources in unfamiliar ways. Consequently, institutions are required to rethink and reorient current strategies to provide appropriate and timely responses. Without a comprehensive institutional transformation, the 4IR can indirectly contribute, as previous industrial revolutions did, to accelerate the concentration of wealth.

Although the benefits of digitalization and automation of production can contribute to an unprecedented rise in value-added generation, they will not necessarily translate into increased prosperity for all.

Developing countries will be under constant pressure to identify and manage the 4IR externalities, in particular the potential risks and negative impacts in the long run. This endeavour should be based on a constant assessment of the potential benefits and disadvantages, the investment required and the implications of required policy reforms and guided by the need to ensure that the 4IR is human-led and human-centred, that is, human values must be respected in themselves, rather than weighed only in financial terms³⁴.

The 4IR introduces new challenges relative to preceding revolutions, the signs of which include: building the future of manufacturing skills; infrastructure challenges and matters of security and privacy. In developing countries, there is a high unemployment rate; digitization and automation extend fear of massive job losses, besides the fact that industrial automation is non-operational in most developing countries.

Low e-readiness levels in developing countries are a hindrance to the transformation towards so-called smart societies. Societies in developing countries commonly possess inadequate skills to reinforce the use of technology in business processes and a comparatively lower capability to produce and adapt technological innovation to assist social, economical and environmental challenges.

Developing countries are also confronted with technical and infrastructural challenges. Telecommunications infrastructures for example, is critical for development of networks and smart devices and their absence imposes a barrier for digitalization and industrial transformation. Security and data privacy issues have arguably become one of the most significant concerns in the 4IR where technology has become a driver³⁵.

The emergence of large technology corporations concentrating digital services poses a challenge to all economies, including the most advanced ones. Globalization and digitalization in the absence of adequate regulation may paradoxically suppress international trade, as the widening productivity gap can trigger protectionist tendencies.

At regional and international levels, mechanisms such as aid for trade, South-South and triangular cooperation with the support of international organizations could be instrumental in overcoming the challenges discussed above.

Although the benefits of digitalization and automation of production can contribute to an unprecedented rise in value-added generation, they will not necessarily translate into increased prosperity for all. Technology does not ensure per se a fair distribution of benefits since their development and implementation is also contingent upon the predominant political and economic paradigm in which they operate. Therefore, it is extremely important to enforce economic political instruments that ensure a broader positive social impact.

A smooth transition to the 4IR also requires developing countries to analyze the political, ethical, environmental and social implications that the innovations and new technologies are required to have, in order to provide assurance that these will not pose any risks to the natural environment or society at large.

In addition, it is well known that one of the main obstacles in the developing countries is precisely the lack of vigilance, regulation and standards for the use of new products. Therefore, it represents a big challenge for these countries on their road to the 4IR.

Developing countries lack resources, skills and expertise in many of the areas of technological development. There is a need to harness the potential of partnership at national and international levels which is not always the case. At regional and international levels, mechanisms such as aid for trade, South-South and triangular cooperation with the support of international organizations could be instrumental in overcoming the challenges discussed above³⁶.

Opportunities of the Fourth Industrial Revolution

The growth of Industry 4.0 stimulates an increase in employment. Changes in education and training systems for different skills will be required. In the short term, the trend towards greater automation will displace some of the often low-skilled laborers who perform simple, repetitive tasks. Effective use of human and material resources is necessary as skills are updated frequently. At the same time, the growing use of software, connectivity, and analytics will increase the demand for employees with competencies in software development and IT technologies, such as mechatronics experts with software skills. (Mechatronics is a field of engineering that comprises multiple engineering disciplines)³⁷.

Digital transformation under the 4IR will generate economic gains, such as increased revenues due to lower transaction and transportation costs. Manufacturers will require enhanced equipment and new data applications as consumers demand a wider variety of customized products, enabling innovation across sectors with a huge impact on economic growth.

The growing use of software, connectivity, and analytics will increase the demand for employees with competencies in software development and IT technologies, such as mechatronics experts with software skills.



The application of emerging technologies enables the SMEs to extract insights from their data to move from reactive to predictive maintenance, pinpoint improvements, reduce waste and increase yield. Furthermore, they can fine-tune quality management and thereby prevent costly reworking of products.

The application of emerging technologies entails more reliable and consistent productivity and better-quality products. Industry 4.0 will lead to increased productivity for the SMEs through the effective use of human and material resources. The application of emerging technologies enables the SMEs to extract insights from their data to move from reactive to predictive maintenance, pinpoint improvements, reduce waste and increase yield. Furthermore, they can fine-tune quality management and thereby prevent costly reworking of products.

The 4IR will facilitate the identification of niche opportunities. Some technologies work based on the classic “slicing up the value chain” approach²¹. For example, artificial intelligence relies on big data for its applications. Activities like data inputs, scrubbing and processing is done in countries with lower wages. These activities can provide employment opportunities to a young and relatively well-trained work force.

The use of Industry 4.0 technologies will enrich the shift to mass customization, for instance additive manufacturing of objects and components, with an increased role for SMEs, driving industrial transformation through pioneering of new opportunities that delivers attractive growth and margins. Enterprises are adopting digital manufacturing strategies from the design phase to reduce risk. In this instance, businesses need to differentiate their products, command premium prices and establish relationships with consumers.

At its broadest level, Industry 4.0 signifies a shift not only in how companies function and how goods would be produced, but how ecosystems—the suppliers, customers, regulatory considerations, investors, and other third-party experts and influencers—would function and interact⁴⁴. Industry 4.0 technologies create the potential for interactions between every point of a network through digital chain networks. Thus, stakeholders can work together more effectively, using a constant stream of data from connected systems to learn and adapt to new conditions, and even begin to predict rather than react.

Changes in the organization of work, with more remote, flexible and on-demand work is becoming a standard²¹. Use of IoT and cloud computing open possibilities of remote work management structures and labour outsourcing. The emerging smart manufacturing improves the health and safety for factory workers as all functions and operations can be automated and digitized.

Emerging technologies is an opportunity for companies to expand operations and broaden visions as they explore innovative ways to deliver customer value. Enterprises collaborate on heavy investments in science, technology, engineering and mathematics (STEM) areas to conceive a foundation for upholding technology applications for industrial transformation.

The Industry 4.0 technologies enhance the accessibility to infrastructure. Adoption and application of emerging technologies compels the development of compatible infrastructure for upholding the applicable versions of technologies. This suggests that prior to adapting and adopting any new technologies, infrastructural development is a prerequisite and hence the way to achieve industrial transformation and social development.



Adoption and application of emerging technologies compels the development of compatible infrastructure for upholding the applicable versions of technologies.

In summary, the 4IR improves the flexibility, speed, productivity, and quality of the production process and it lays the foundation for the adoption of new business models, production processes, and other innovations. This will enable a new level of mass customization as more industrial producers invest in digital technologies to enhance and customize their products.

The Circular Economy Concept under Industry 4.0

The accelerated pace of digitalization, strong demographic growth, and current consumption levels are placing the environment under enormous pressure. The operation of the dominant economic model is characterized by a continuously growing extraction of natural resources and the generation of large amounts of waste.

Sustainable development requires disruptive changes in the way our societies and businesses are currently organized. The Circular Economy (CE) model offers better integration possibilities between natural ecosystems and our daily economic activities. The transformation of the current linear economic system to a circular one offers many opportunities to advance sustainable natural resource use by creating closed-loop supply chains and implementing sustainable recycling management.

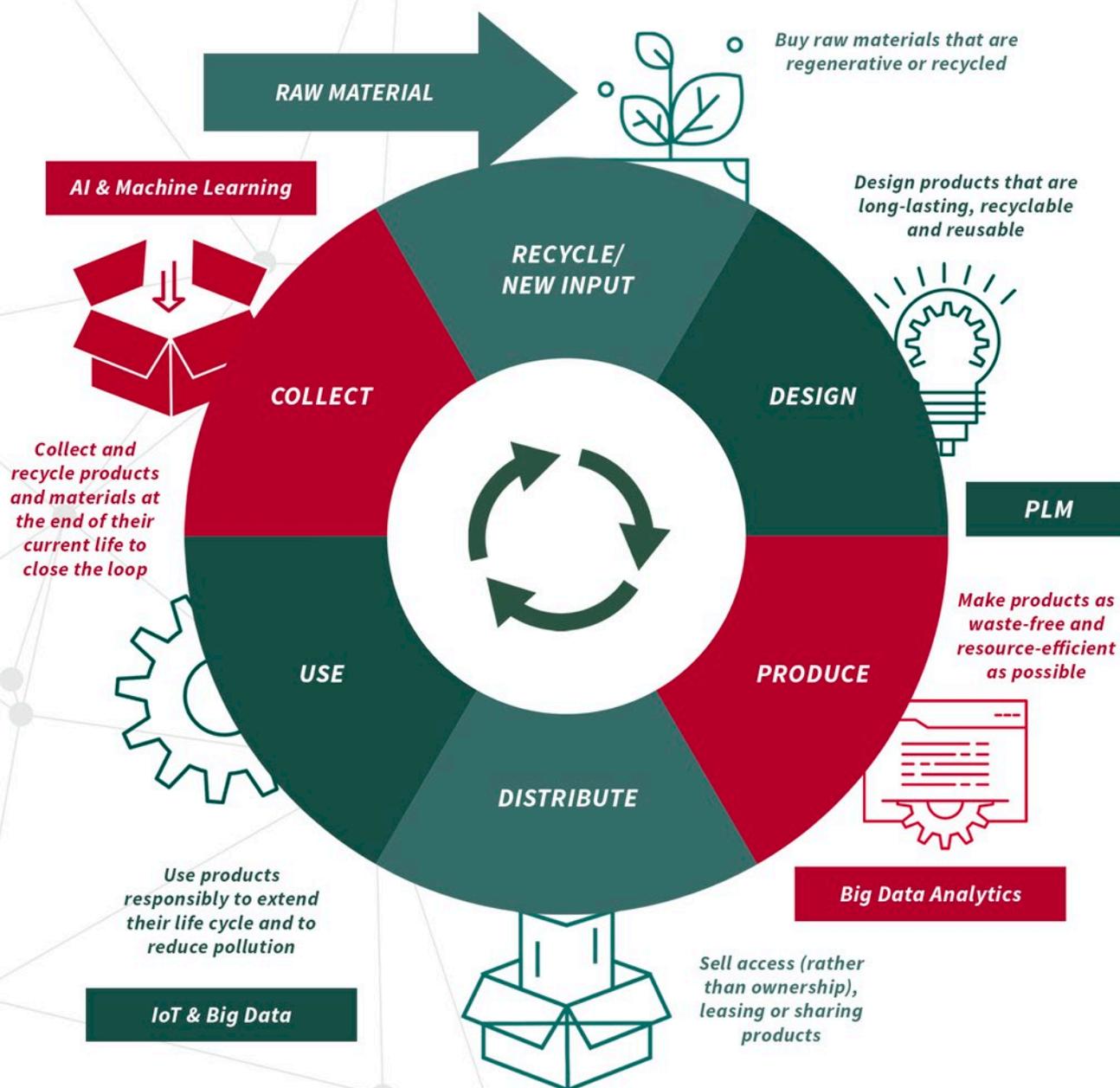
The CE is a model of both production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. CE promotes economic activities oriented to preserve the value created, either in the form of labour, energy or materials. In this way, not only the life cycle of products is extended but also the value is preserved. CE strategies could lead countries towards a more sustainable development path that avoids locking in resource-intensive economic practices of the dominant linear consumption and production system. Some developing economies are in many ways more 'circular' in terms of resource management, production and consumption practices in comparison to developed economies. The challenge is how to turn this into a development opportunity³⁹.

CE can provide a broad vision or tackle a specific sector. It casts a wide net concept, so policymakers and businesses alike want to take advantage of its enormous potential. Effective policies incorporate strong incentive mechanisms that focus on both financial support and non-financial measures that create market opportunities for circular products, services, and business models (such as green public procurement). Taking the right measures to unlock these incentives requires a degree of synergy behind policy alignment and collaboration across sectors. Co-creating momentum by linking the CE with mainstream social or economic policies can serve as a powerful tool to draw support from additional networks and access capital⁶⁶.

Circular business models encompass one or more of the following:

- **Circular design:** developing products and materials with the aim of long-term value retention
- **Optimal use:** supporting prolonged usage and product productivity
- **Value recovery:** capturing value even after the product reaches the end-of-life stage
- **Network organization:** organizing and coordinating a community that enables circular business models⁶⁷

Figure 10 Circular Economy Activities Along the Value Chain and Potential Technology Applications



Source: Michael Hanf (2019)⁴⁰

<https://www.taival.com/stories/circular-economy-what-is-it> and own elaborations of technologies (2020)

Product Lifecycle Management (PLM) systems support the transition to the CE. They help integrate information across multiple life cycles and across various stakeholders in the value chain. PLM systems enable monitoring of products and parts in multiple lifecycles. In particular, PLM systems enable near time consumption and optimization of stock and material flows. Product life extension extends the working lifecycle of products or components by reselling, repairing, remanufacturing and upgrading, which promotes a different revenue model for the product⁴¹.

Within the context of CE, Big Data analytics is seen as a viable approach to make use of information from various systems of record such as IoT sensors, to enable better decision making. Big Data can integrate lifelong information and enable the implementation of new strategies. The capabilities of application of Big Data on circular innovation to monitor processes of production and consumption makes it vital for allowing material flows to be closed easily⁴².

Use and or sharing of products enable increased utilization rate of products by making possible shared use or access or ownership. From this way of operating, a different business model is formed, the facilitation of which is strongly guaranteed by IoT. Offering a product as a service (PaaS) under the CE model entails offering product access and retaining ownership to internalize benefits of circular resource productivity. An example is the growing e-scooters and carsharing platforms that offer customer mobility products as a service. A greater public acceptance of such business models could incentivize producers to make vehicle parts easier to replace or repair, thus reducing the overall use of resources.

Another main issue of concern on the circular concept is resource recovery- recover materials, resources and energy from disposed products or by-products. This entails the use of circular supplies, that are bio-based or fully recyclable input materials to replace toxic and single life cycle inputs.

The CE is all about lengthening the lifecycle of resources and minimizing waste; obtaining the maximum value from the resources after use and regenerating products and materials at the end of their useful life. These fundamentals create various opportunities for businesses to monetize data through AI algorithms and data analytics or apps. Migration and sharing economic trends help foster this, considering that more people are looking for the combination of convenience, good user-experience and the possibility of using a product or service without possessing it.

Innovation and data-driven CE will promote economic competitiveness. Adapting to the need for preserving finite natural resources and concerns of environmental impacts, the CE principles have high capabilities to solve challenges in developing countries. The current linear growth models based on “take-use-dispose” and the GVCs that support this system will incapacitate developing countries to achieve development goals thus it is crucial for them to develop CE tools.

Industry 4.0 technologies play an important role in the transition towards a CE by optimizing forward material flows and enabling reverse material flows. In that regard, CE is following a similar trajectory with product/service system (PSS) and service ecosystems in general, where digital technologies have been a critical enabler. Reflecting on PSS, digital technologies that have been recently introduced like IoT and Big Data have a strong potential and can help develop PSS that are environmentally friendly.

Circular economy in Mexico

In the case of Mexico, some important milestones have been set towards CE concepts. The government defined regulatory frameworks and developed public policy instruments. For instance, the national programmes for the “Prevention and Integral Management of Waste” which seek to improve waste management approaches and to minimise the impact on the environment, and in particular on human health. Another document entitled “National Vision towards Sustainable Management: Zero Waste” that was published at the beginning of 2019 supports the adoption of CE initiatives.



Industry 4.0 technologies play an important role in the transition towards a CE by optimizing forward material flows and enabling reverse material flows.

Furthermore, a roadmap was developed on how Mexico can advance towards achieving CE models. The document specifies the required design and implementation of public policies, as well as the application of instruments, programmes and plans, to reinforce the management of waste in the country. Based on an analysis of the country, the roadmap documented six guiding principles with the objective to lay the foundations to strengthen the sustainable use and management of materials in the country with a zero-waste vision. The scope of the roadmap is primarily focused on solid waste, considering the biggest issue facing Mexico in terms of waste is size and number of open dump sites and sanitary landfills, both legal and illegal.

To reduce the risk of exposure to waste in landfills, the document directs the action to the flows and processes of classification, collection, transport, transfer, reuse, recycling, storage and recovery into new valorised materials and energy. The vision presented aims to bring forward these concepts to allow for the gradual reduction of solid waste and to reduce and finally close solid waste landfill sites. The response from the public sector in providing a vision for a CE in Mexico has in many regards already been met by the private sector as they see a market niche and an economic gain in moving towards a CE.

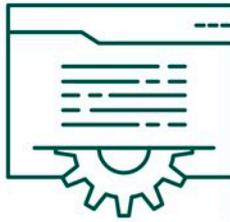
The application of CE generates a positive impact in many industries, by virtue of continuous product reuse, recycling and remanufacturing. The main advantage is that while supporting the manufacturing industry and increasing its competitiveness, circular principles inspire innovations and innovative financing mechanisms, such as impact financing. In addition to generating financial returns, investments can create jobs and thus have a positive impact on the society and on the environment. Impact investment goes beyond avoiding harm and managing risk and aims to generate a positive social or environmental impact alongside a financial return⁴³.

The CE model enriched with the synergies of technology is a powerful and potentially highly productive combination. Mexico must grow in the application of Industry 4.0 technologies to increase potential achievement of set circular principles.

Quality Infrastructure of the 4IR

The 4IR poses important challenges for measuring, testing and certifying new products. AI and machine learning, for example, have introduced significant difficulties for both authorities and companies. For instance, how can we certify a product that is constantly changing and that continues to learn throughout its useful life? And what are the most appropriate measurement units to quantify and calibrate artificial intelligence products? As during the first industrial revolutions, the QI will continue to be a fundamental component in the development and consolidation of technological innovation. For this, QI needs to be systemically transformed to meet the new needs of the industry. Previously, QI had to evolve in tune with the Industrial Revolution that originated in Europe in the 19th century. In this sense, QI must acquire the same dynamism and pace in which industry and technology are currently moving forward.

The key institutional components in Quality Infrastructure Standards (QIS) are made up of the high-level institutions responsible for:



STANDARDIZATION

Is usually the responsibility of a National Standards Body (NSB) that may represent the country's interests within organizations such as ISO (the International Organization for Standardization). The NSB may provide for national delegations to participate in the development of standards that are of key importance to their country's economy.

METROLOGY

The science of measurement and it is a vital part of everyday life. Accurate measurements and measuring equipment are needed for the protection of health, safety, the environment and consumers. They are vital too in contracts between individual business partners and in world trade in general.



CONFORMITY ASSESSMENT

The name was given to the processes and procedures used to demonstrate that a product or a service, management system, organization or personnel meet specified requirements. These requirements are usually stated in international standards developed by organizations such as ISO.

ACCREDITATION

The process by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks. Its official approval is known as "accreditation" and will indicate to customers and users of the services of these organizations that they can have confidence in their work⁵⁰.



MARKET SURVEILLANCE

Activities, conducted by market surveillance authorities (usually under government responsibility), aim to verify whether products and services on the market comply with applicable regulations.

QI must also be seen as a facilitator of innovation. The institutions and services of the QI, such as standardization and conformity assessment, are cornerstones in the development and adoption of new technologies. Therefore, it is necessary to accompany the enforcement of national science and technology with investments aimed at strengthening quality infrastructure. In Germany, for example, the lack of equivalent standardization investments to match the amount of resources allocated for nanotechnology R&D during the 1990s represented a major obstacle for technology adoption at an industry level. Similarly, the absence of standardization hampers the ability of governments to both design and enforce regulations.

The 4IR offers smart manufacturing technologies which add new and various ramifications within the inspection process. Smart factories will find these production technologies essential for success. The objective is to establish an efficient production system that allows product customization hence promoting manufacturing on a global scale.

Smart metrology enables high transparency of the entire value chain process. The procurement process becomes smarter, faster and easier if metrology equipment is installed within the factories. Industry 4.0 technologies heavily rely on connectivity for operating together efficiently, both technically and organizationally. Inter-connectedness needs better data flow and visibility, which implies that it is essential to have interoperability.

Smart metrology enables high transparency of the entire value chain process.

The Industry 4.0 revolution is seeing the science of inspection rapidly evolve. Manufacturers need to adapt their inspection processes to overcome physical barriers and close the gaps in metrology information at each stage of the value chain in order to support digital, autonomous production. Current factory settings with industrial robots and automated material handling relies on automated control systems built on timely verifications and feedback. Inline metrology is carried out during manufacturing as part of the process to reduce scrap by detecting problems earlier and provides an opportunity to correct the problem in process to reduce rework impact⁴⁴.

Non-contact metrology, which includes laser scanners, phase-based laser scanning and optical systems, are important aspects of smart factories. This type of measurement allows for high-resolution scanning of parts as well as long-distance maneuvering of measuring devices. Introduction of robots in the manufacturing process has proven to increase accuracy, reliability and continuous production. Robots are not usually designed to measure parts, nonetheless it is possible to adapt them for inspection particularly for larger volume components. Recent generations of robotics are continually getting smarter and improving accuracy, demonstrating that machine-based measurement and inspection will heighten.

Some accredited certification and inspection bodies have developed cloud-based systems to provide greater insight for customers and their supply chains. UKAS (United Kingdom Accreditation Services) is developing a database to support supply chains with access to data and detailed quality performance KPIs on supplier, auditor and certification body performance. Digitalization is becoming more common in customer relationship management through self-service and digital platforms to support the management on customer assessments. Data analysis will enhance the oversight by conformity assessment bodies through continuous monitoring of competence and performance analytics. This path will ensure that accreditation, the Testing, Inspection and Conformity (TIC) entities and other traditional quality infrastructure partners remain relevant and continue to be a provider of trust⁴⁵.

The major areas for Industry 4.0 market applications indicates a significant growth potential for sensors. Sensor deployments in the areas of process control, automated production lines, and digitalized supply chains are slated to increase in the coming years. Sensor technology leverages fully enabled connectivity and data sharing and integration with logistics, and hence supply data and feedback from the market on the functionality of products and or services.

Data analysis will enhance the oversight by conformity assessment bodies through continuous monitoring of competence and performance analytics.

The adoption of 4IR technologies has extrapolated the problem of interoperability. New digital technologies bring new interfaces and, in most cases new technical requirements. Similarly, local improvements and adaptations of existing technologies will require evaluation and certification to be used in other markets. In both scenarios, the QI makes an invaluable contribution.

The 4IR is facilitating communication between a growing numbers of devices without the need for human intervention. This new possibility has raised concerns related to cybersecurity. In this sense, the QI can contribute to ensuring that the different elements that make up the system are suitable for the purpose for which they were designed and that they meet requirements and quality standards.

The QI can effectively assist the development of efficient internal markets, facilitate access to foreign markets and help to promote economic development. For successful trade, manufacturers must ensure that their products are of consistently high quality, complying with the relevant standards and meeting the requirements of the consumer.

In combination, all five pillars of QI are of critical importance for developing countries since they constitute a system that supports national policy objectives in key areas including industrial development, trade competitiveness, efficient use of natural and human resources, food safety, human health and environmental protection.

Quality Infrastructure in Mexico

The Mexican Government has implemented a number of projects to strengthen QI for supporting several industrial sectors and economic activities, such as the Global Project Quality Infrastructure (GPQI), commissioned by the German Federal Ministry for Economic Affairs and Energy in 2018 which aims to promote the international harmonization of regulatory and technical requirements for trade and industrial transformation.

In mid-2019, the Mexican Government presented a comprehensive reform of the existing Law on Metrology and Standardization. Its overall objective is to introduce a harmonized system in which the individual pillars of QI (standardization, conformity assessment and metrology) are not viewed in isolation thus promoting a systemic view of the Quality Infrastructure system.

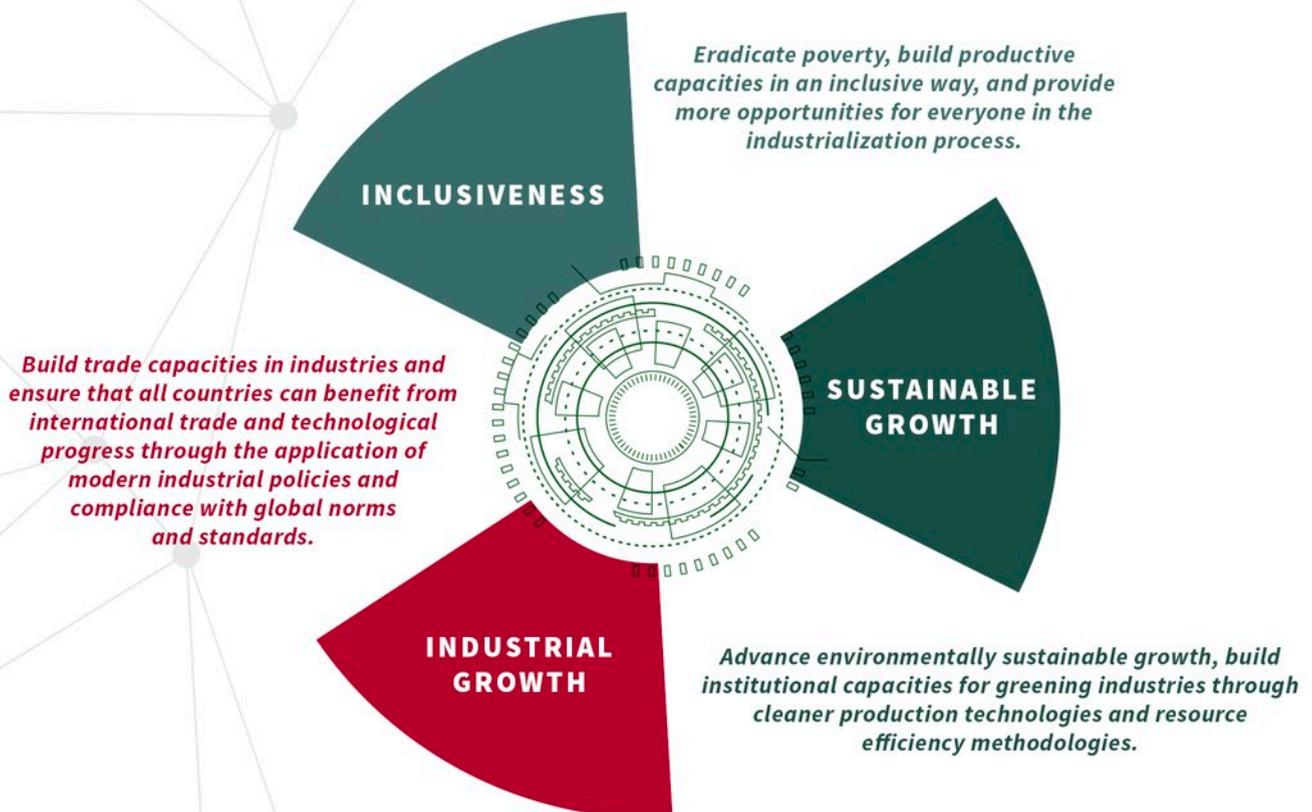
The reforms aim to strengthen conformity assessment procedures. Their development will be carefully noted by the level of risk or protection of the Official Mexican Standards (NOM), which are entrusted exclusively to government bodies. The elaboration of NOM shall become more agile and efficient by using IT and communication technologies. This includes, for example, the use of a new Integral Platform for Standardization and Conformity Assessment to be established for procedural processes, the preparation of NOM and as information archives. Moreover, the reforms are anticipated to establish clear and effective rules for the elaboration, modification and cancellation of NOMs and requirements for the standardization process and a systematic review process to be introduced in which the reasons for the need to modify or cancel NOMs must be stated.

A distinctive feature of the new Quality Infrastructure Law for strengthening QI in the country is built upon an incentive system focused on the private sector. It aims to improve compliance with the NOMs through a manufacturer self-declaration system and signing of Mutual Recognition Agreements (MRAs) by accreditation and conformity assessment bodies, while the Ministry of Economy will promote the facilitation of international trade.

2.3 UNIDO Strategic Approach for Industry 4.0

UNIDO facilitates the transformation towards the 4IR. UNIDO's mission is to foster ISID through the development, transfer and adaptation of advanced technology on global, regional, national and sectoral levels. ISID is an integral part of the global development agenda since it has an impact on all three pillars of sustainable development. Similarly, due to the interlinked nature of the SDGs, many of UNIDO's actions contribute to more than one SDG. Particularly, UNIDO's contribution to SDG 9, which calls for "Building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation", recognizes that industry and industrialization are the main drivers of sustainable economic growth, environmental sustainability and shared prosperity, as shown in Figure 11.

**Figure 11 Main Contributions of UNIDO to SDG9:
Industry, Innovation and Infrastructure**



Source: UNIDO (2018) *Industry 4.0-the opportunities behind challenge*
https://www.unido.org/sites/default/files/files/2018-11/UNIDO_GC17_Industry40.pdf

Based on this premises, UNIDO aims to ensure that its Member States take full advantage of breakthroughs in 4IR digital technologies (i.e. AI, robotics, 3D printing, and the Internet of Things) and convergent technologies (nanotechnology, biotechnology, information and communication technology and social sciences and humanities). Digital technologies hold in fact enormous potential to promote ISID and to advance the sustainable development agenda. UNIDO's vision is to become a leader in addressing the set of opportunities, challenges and negative externalities arising from the 4IR digital technologies and how these can impact ISID and economic development.

To achieve its vision and mission, UNIDO proposes to take action on strategic areas divided into 4 thematic areas and 4 cross cutting areas, in alignment with the organization's programmatic framework, as follows (see also Figure 12)⁴⁹:

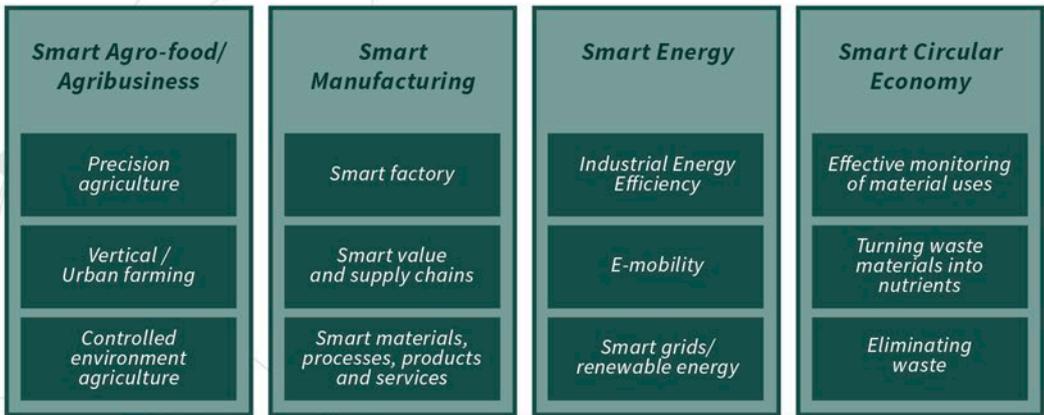
Thematic areas

- **Smart agro-food:** Addressing food security and incorporating disadvantaged and vulnerable populations and small and medium enterprises through 4IR technologies and circular economy models.
- **Smart Energy:** Realizing efficiency and increasing the uptake of renewable energy through smart and artificial intelligence-based energy approaches.
- **Smart manufacturing:** Ensuring smooth transformations to smart manufacturing with an integrated and holistic portfolio of services.
- **Smart circular economy:** Advancing the circular economy through research, communication, technology and standards.

Cross-cutting areas

- **Knowledge creation and commercialization,** technological learning and innovation of firms, and skill-building.
- **Inclusion of disadvantaged and vulnerable population groups** suffering from structural discrimination such as women, youth, older persons, persons with disabilities, ethnic minorities and indigenous peoples and promoting SMEs.
- **Institutional transformation and innovation:** norms, standards and conventions.
- **Leveraging multi-stakeholder partnerships.**

Figure 12 UNIDO's 4IR Thematic Areas and Cross-Cutting Issues



UNIDO CORE FUNCTIONS
 Technical cooperation, analytical and research and policy advisory services, normative function and standards-related activities, and convening function and partnerships

Source: UNIDO's Strategy for the Fourth Industrial Revolution, 2019⁴⁹

Industry 4.0 Activities and Tools

UNIDO promotes digital transformation and innovation ecosystems building, to advance the economic competitiveness of developing countries by helping them to benefit from the rapid progress of digital and convergent technologies associated with the 4IR. To ensure a smooth transition UNIDO offers a broad range of services, including:

- Supporting the preparation and execution of 4IR readiness assessments. This involves preparation of strategic roadmaps, the development and consolidation of 4IR transition strategies.
- Promoting the development and upgrading of business infrastructure and regulatory frameworks to enable the adoption of new digital technologies and business models; improve competitiveness and promote inclusive and sustainable industrial activities.
- Assisting governments and the private sector with the development of advanced technology foresight analysis and benchmarking to carry out policy reforms and devising far-reaching industrial development strategies.
- Supporting the development and modernization of quality infrastructure systems, including an analysis of national and regional quality policies and institutional mechanisms for standardization, accreditation, metrology conformity assessment and market surveillance and the application of new technologies for traceability, inspection, metrology and other quality infrastructure related services.
- Facilitating closer collaboration ties between academia, government and private sector by providing assistance to governments in leveraging the potential and establishment of science and technology parks, innovation hubs, learning and lab factories, start-up incubators programmes.
- Assisting in the development of innovation ecosystems for enabling product, process, functional and value chain industrial innovation by establishing collaborative knowledge sharing-platforms and innovation funding support mechanisms and schemes.
- Facilitating the exchange of ideas, knowledge and expertise and the formation of strategic alliances between academia, governments, private sector and civil society, to harness the potential of new technologies and advance the 2030 Agenda for Sustainable Development.
- Promoting foreign direct investment in national strategic sectors by identifying international investors, technology providers and SMEs with greater potential to benefit from technological upgrading.

UNIDO helps countries to tap into the vast potential of 4IR. While some technologies are exotic, expensive and hardly useful in their current stage, there are sensors and technologies that could be adopted at low-cost. The potential of low-entry barrier technologies and their quick dissemination can have a demonstrative effect and help the dissemination of 4IR technologies.



UNIDO implements project initiatives according to the needs of the Member States. The role of UNIDO is to implement capacity building packages through development of strategic frameworks for adaptation and adoption of 4IR at all levels: macro-, meso-, and micro. UNIDO has established international guidelines for industrial parks, a guidebook and training tool for SMEs on ISO 56001 on Innovation Management System Standard, training tools on e-commerce development, training packages on Industry 4.0, and guiding tools on moving to digital kaizen and enterprise modernization and innovation programmes, all of which supports adaptation to Industry 4.0 technologies.

Through the integrated Enterprise Modernization and Innovation Programme (EMIP), UNIDO supports Member States in keeping abreast of the innovations and technologies at policy, institutional and enterprise levels. Manufacturing enterprises are modernized through technology transfer, technical knowledge dissemination and introduction of innovative processes. This may include digitization and automation of industrial designs and production processes, utilization of e-commerce tools and enterprise management practices. National consultancy and business development services are improved to match the growing demand for 4IR methodologies in manufacturing enterprises through capacity building and direct involvement in the implementation of upgrading activities aimed at speeding up the transition to Industry 4.0.

In this respect, UNIDO offers services that aim to connect academia, the private sector and the international community to accelerate the pace of absorption and knowledge dissemination required for integrating 4IR technologies into a country's economic system. UNIDO has adopted a conservative approach along the value chain processes in different industrial sectors. The approach promotes Industry 4.0 readiness analysis, technological needs assessment and potential relevant emerging technologies applicable at each value creation stage. This is done with a specific focus on the following technical modules; skills and capacity building, SMEs and MSME digital transformation, sector-specific technology adoption, smart platforms and ecosystems of innovation. Examples of the components under each technical module are shown in Figure 13.

Figure 13 UNIDO's Technical Modules for Assisting Countries to Transition⁴⁶

SKILLS AND CAPACITY-BUILDING

- Raise awareness of 4IR opportunities and challenges for pursuing inclusive and sustainable industrial development in different developing country groups.
- Design technical and vocational education and training schemes.
- Support the establishment of demonstration and innovation centres and start-up programmes.



**SME
MSME**

SME AND MSME DIGITAL TRANSFORMATION

- Assess SME preparedness for 4IR uptake using UNIDO methodology.
- Set up entrepreneurship and start-up programmes in new digital technologies, especially for disadvantaged population groups.

SECTOR-SPECIFIC TECHNOLOGY ADOPTION

- Address product, process, functional and value chain innovation by using new digital technologies and new materials and business models.
- Provide capacity-building activities to independently undertake 4IR readiness analysis for the preparation of roadmaps and to monitor the uptake of new technology at the industry level.

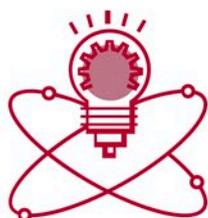


SMART PLATFORMS

- Promote global e-commerce adoption, innovation, investment and development.
- Advocate the importance of quality infrastructure and international standards in e-commerce.
- Promote 4IR in smart and sustainable city initiatives.
- Leverage multi-stakeholder resources on international networks from international organizations and institutions, DFIs, the private sector, academia, and civil society centres and start-up programmes.

STANDARDS AND INTEROPERABILITY

- Foster international cooperation and the use of harmonized new standards and business protocols for interoperability in the context of the 4IR and for reducing the possibility of conflicting national and regional standards.
- Mainstream business environment reforms including on legal, policy and regulatory frameworks for digital economy uptake by using digital technologies.
- Ensure industrial safety and security through regulations, standards and adoption of 4IR technologies.



ECOSYSTEMS OF INNOVATION

- Develop science and technology parks and areas of innovation.
- Strengthen systems of innovation on the national, regional and sectoral levels for 4IR.
- Broker multi-stakeholder partnerships.
- Smart technologies for low-cost housing and innovation hubs and smart industrial parks that are established in urban or peri-urban areas.

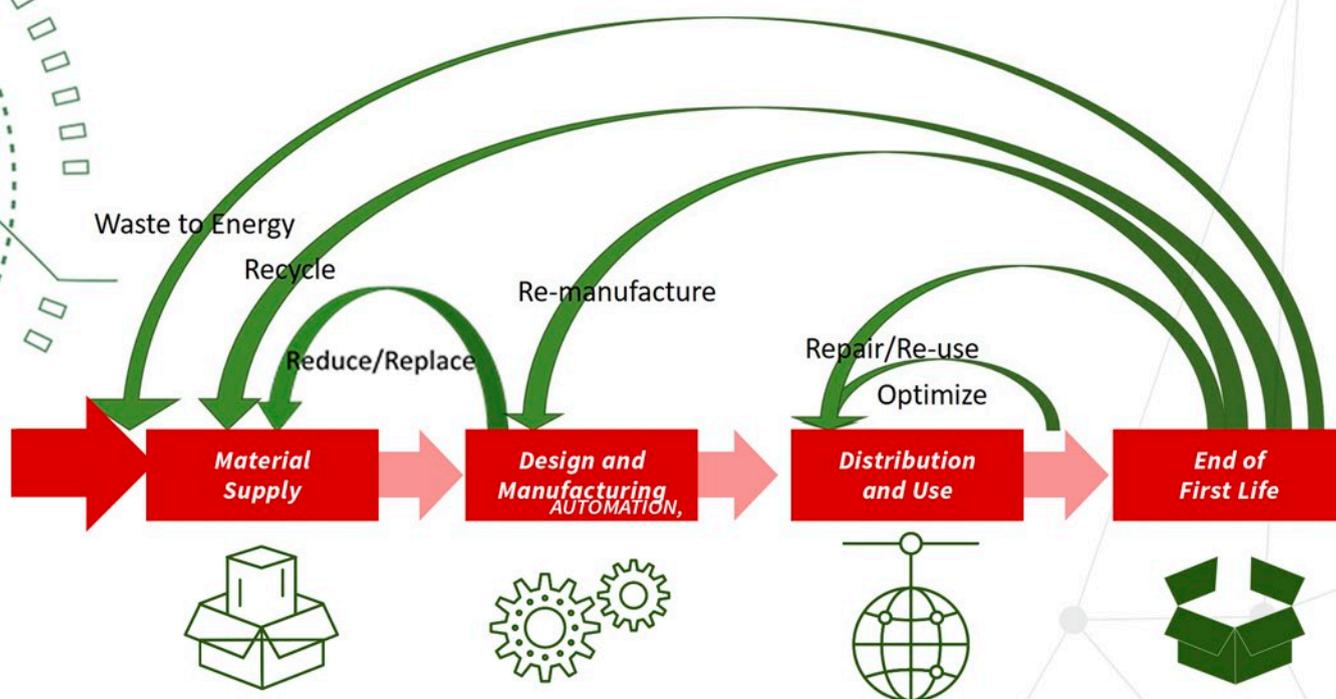
UNIDO and Circular Economy

UNIDO defines circular economy as an industrial economy that routes materials, parts and products back into use several times and creates more value and less waste. It is an alternative in which value is maintained for as long as possible, products are designed to last, and the generation of waste is minimized⁴⁷. An economy achieving full circularity enables stakeholders to aim high when setting their vision, priorities and strategies for inculcating circular practices within industries and societies for a better future. Through circular practices and business models – reduce, replace, regenerate biomass, repair, refurbish, re-manufacture, reuse and recycle, product-as-service, and waste-to-energy, materials lifecycles are lengthened, and they are reused as an input material, part or component, or energy source, or as a last resort, disposed of. The retained value in products and resources creates new business opportunities, income and employment⁴⁸.

UNIDO supports the adoption of circular economy principles that would lead to higher resource efficiency and less waste and is one of the leading UN agencies implementing and monitoring Sustainable Development Goal (SDG) 9. The 4IR contributes to the application of the concept of the CE in different industrial sectors, where products that reach the end of their useful life are reused and recycled. This facilitates access to new benefits and opportunities, creating new markets, improving the value chain and reducing the amount of waste in production, thus safeguarding the environment.

Some technical projects done by UNIDO are already addressing various building blocks of CE principles. Other initiatives support resource efficient and smart manufacturing of products, others are at the design level to assist adoption of easy-to-recycle products with lengthened lifecycles as well as the recovery or safe disposal of resources at the end of a product's useful life. CE creates value and prosperity in the different industrial sectors, contributing to more interoperability and flexible industrial processes and autonomous and intelligent manufacturing. Figure 14 below shows the linear supply chain which used to dominate past practices and circular economy principles applied for natural resource use improvements.

Figure 14 Circular Economy



Source: UNIDO, Industrial Resource Efficiency Division and CIRCULAR ECONOMY Department of Environment, 2019



UNIDO's programme for the smart circular economy aims to advance circular economy models with the use of 4IR technologies. UNIDO's programmes for promoting smart circular economy focus on:

- Conducting research to support evidence-based policy advice on promoting links between 4IR and the circular economy.
- Building awareness of the intersections of the circular economy model with 4IR technologies and business models, and sharing experiences and best practices.
- Developing technologies, products and services conducive to sharply reducing emissions and enabling higher energy and resource efficiency, greater reusability and recyclability, and better environmental performance.
- Creating platforms for monitoring the energy and material resource intensity of 4IR technologies and business models.
- Promoting circular economy models using 4IR technologies for small and medium-size enterprises.
- Ensuring that regulations, standards and incentives support resource-efficient and environmentally friendly production and a sustainable supply of raw materials.
- Fostering traceability, together with data structured and information integrated into smart design processes, enabled by block chain technology.

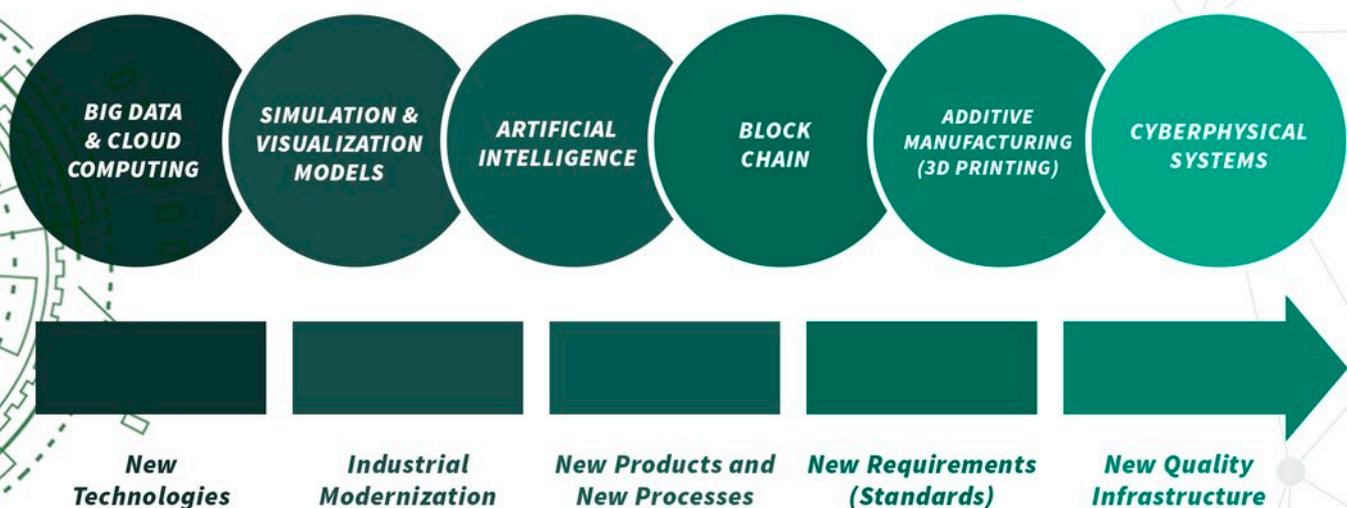
Increasingly, companies are applying innovative solutions, through the “Internet of Things” (IoT), cloud computing, miniaturization, PLM and 3D printing that will enable more interoperability and flexible industrial processes and autonomous and intelligent manufacturing. In this way, the 4IR contributes to the application of the concept of the CE in different industrial sectors, where products that reach the end of their useful life are reused and recycled. UNIDO supports the utilization of Industry 4.0 technologies in the transition process of its Member States.

UNIDO and Quality Infrastructure

UNIDO has more than 40 years of experience in working with governments, industry and other major stakeholders to develop and strengthen national and regional QIs. Such programmes are one of the specialized services that UNIDO offers among its overall activities to promote ISID. These programmes provide developing countries, and economies in transition, with opportunities to eradicate poverty and develop sustainably.

ISID also helps them to build their industrial base as a platform for social inclusiveness, economic competitiveness, environmental sustainability and integration with the global trading system. The institutions and services of a QI provide policymakers, businesses, and other stakeholders with core knowledge about best practice and the tools needed for its implementation. Metrology is constantly evolving, being driven by emerging technologies, as shown in figure 15. New technologies require new standards. New risks require new approaches, which implies the importance of innovation for enterprises.

Figure 15 Emerging Technologies Requirements



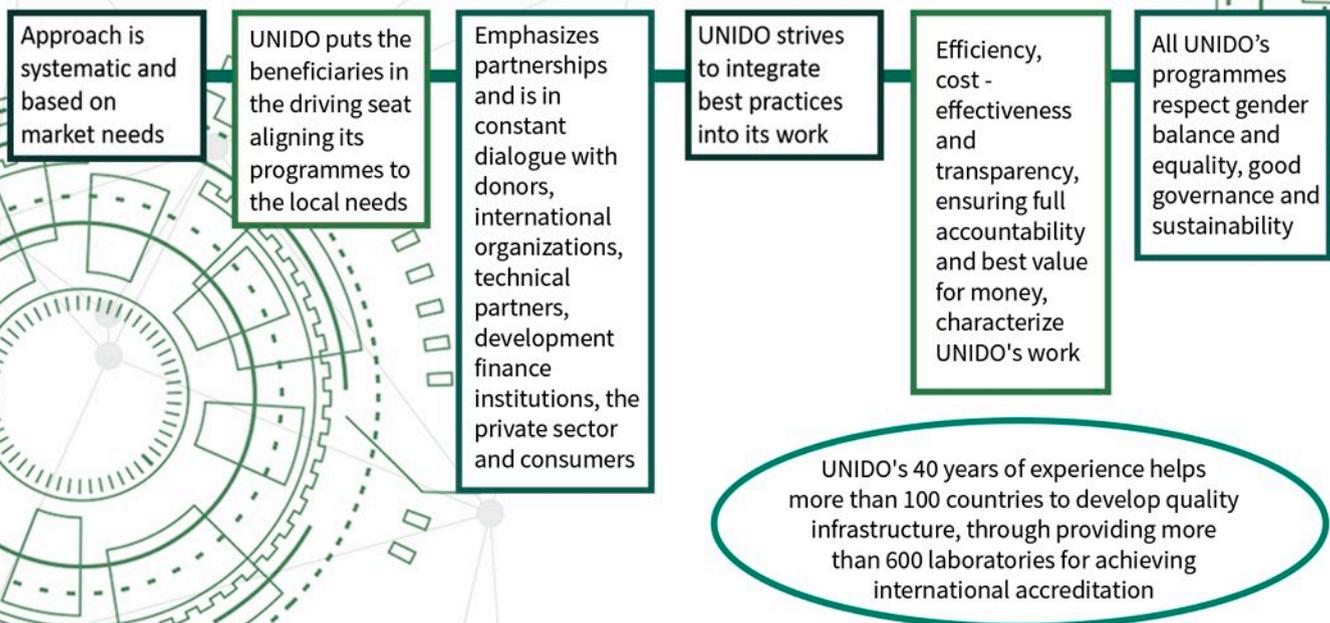
Source: UNIDO Presentation by Mr. Calzadilla Sarmiento at GMIS Connect event in New York (Sept. 2019). Panel on Standards for the Digitalization of Inclusive and Sustainable Value Chains.

UNIDO's approach is holistic, from building awareness of QI to helping initiate, develop and strengthen a fit-for-purpose QI that operates efficiently and cost effectively. The approach emphasizes the need for strong collaboration with all stakeholders to meet shared objectives through agreed activities leading to concrete actions. UNIDO works with partners from the public and private sectors, academia, national, regional and international organizations in charge of standard-setting and global practices on metrology, accreditation, standards and conformity assessment. It promotes good governance, advocates good practice, supports capacity-building and knowledge development, and fosters global cooperation in standards-setting, measurement and compliance along value chains.

UNIDO contributes to improving the quality infrastructure in its Member States, providing the capacity to procure products and services with quality requirements expected by national and international authorities deemed fit for the marketplace. Furthermore, UNIDO helps countries define quality-related policies and good governance strategies, strengthen metrology, standardization and accreditation services, build conformity assessment capacities, enhance the competitiveness of the private sector and promote quality awareness.

The upgrading of quality infrastructure is very important to make it effective in the 4IR environment. The reasons and characteristics of UNIDO's work to achieve quality infrastructure in countries in transition to the 4IR can be seen in Figure 16.

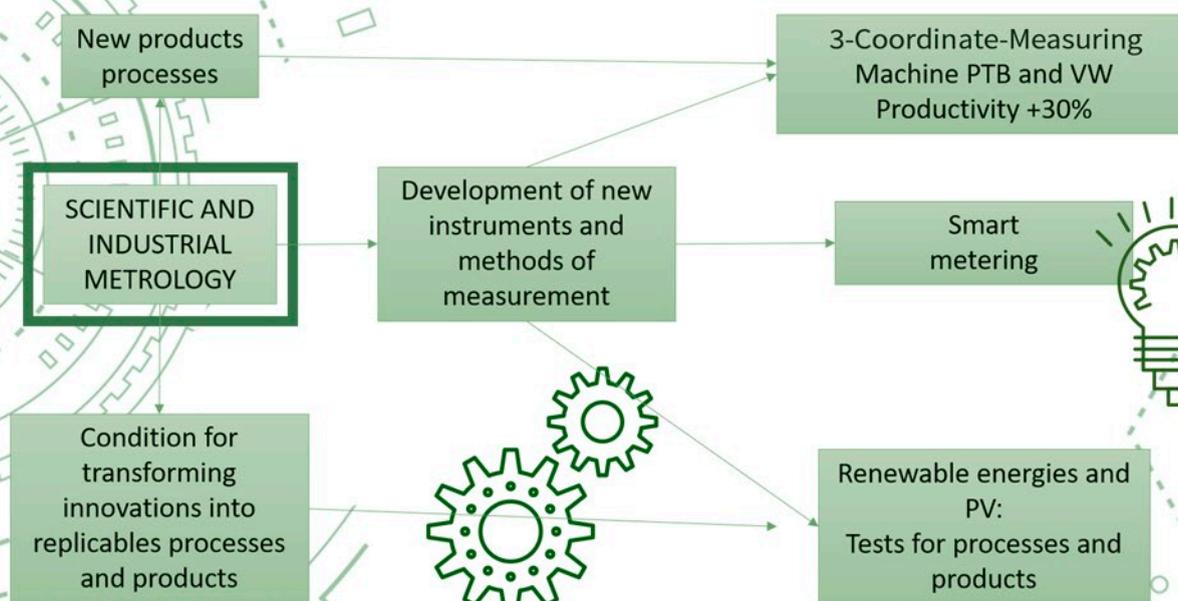
Figure 16 Reasons for countries to work with UNIDO in developing their quality infrastructure¹



Source: *The Fourth Industrial Revolution: benefits and threats for commodity-dependent developing countries.*
https://www.common-fund.org/wp-content/uploads/2019/07/CFC-AR-2018_4th-Industrial-Revolution.pdf

Updating the quality infrastructure system is necessary to increase industrial productivity and innovation in enterprises. Quality and innovation in the 4IR derive from modern and good quality infrastructure. To improve the transition of developing countries to the 4IR, enough evidence is required from existing methodologies that developed countries follow to achieve a quality infrastructure that leads them to be part of the 4IR. An example of this is the metrology strategy followed by Germany to enable the 4IR domestically by means of a quality infrastructure (Figure 17).

Figure 17 Metrology in Germany is Enabling Innovation in Industry 4.0



Source: Karl-Christian Gothner, German National Metrology Institute (PTB), presentation at the PTPR Peer Learning group (PLG) of Colombia, Paris, 26 June 2018.

In this context, in Latin America, UNIDO works with ECLAC closely to develop a statistical system with indicators to measure ISID implementation in the region and to enhance the exchange of technical information on value chain development in specific sectors. UNIDO also cooperates on ISID implementation in those value chains with an emphasis on energy efficiency and quality infrastructure development. International networking is being promoted by linking LAC countries with UNIDO Investment and Technology Promotion Offices (ITPOs) and the South-South Centres' global network³⁰.

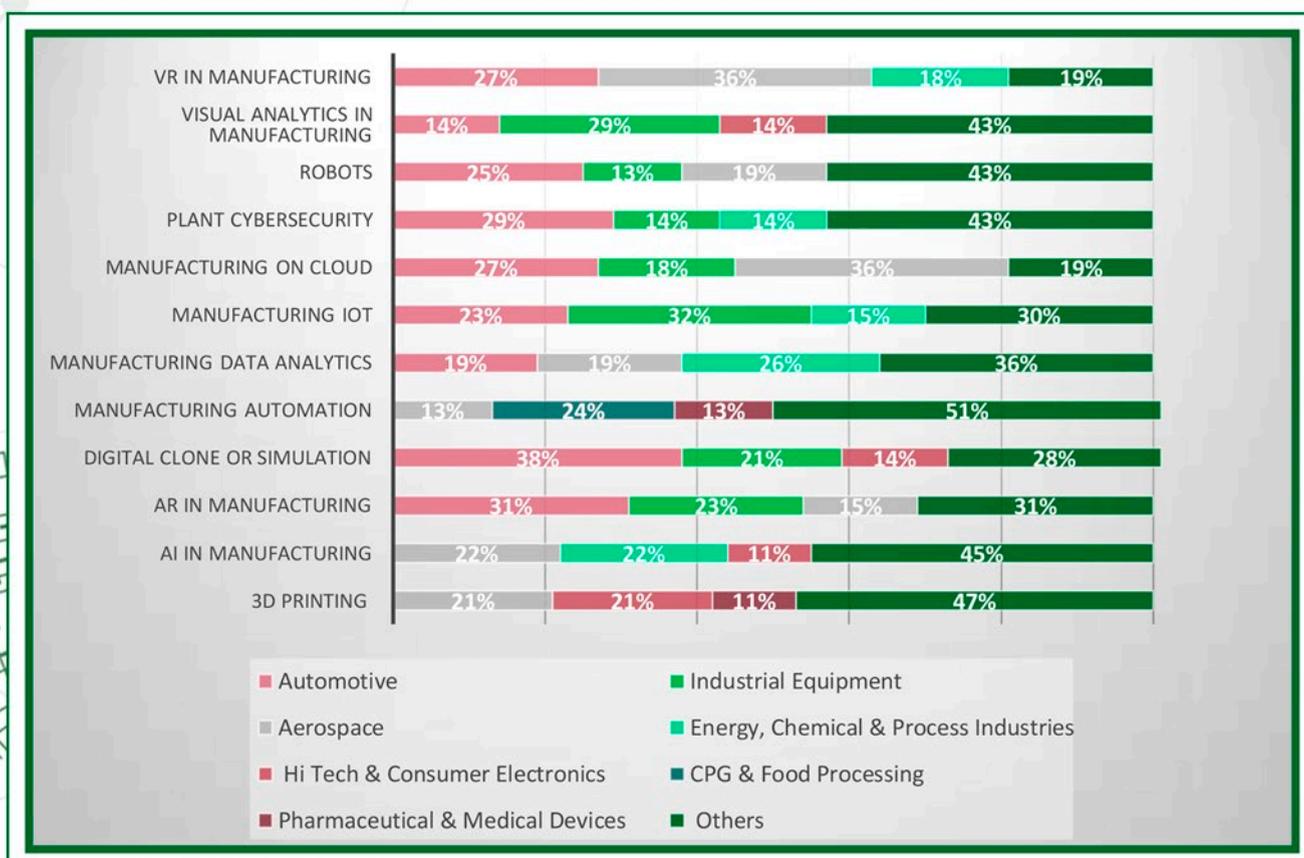
Application and Market Trends of 4IR Technologies and Trends by Industrial Sectors

As one of its strategies, UNIDO is laying the groundwork to promote and accelerate the uptake and dissemination of 4IR technologies. A combination of brownfield and green field activities are particularly challenging because of the nature of some of the technologies. Therefore, early pilot projects and activities are regarded as valuable lessons learned and as experience that can be adapted to the specific contexts.

UNIDO is promoting a value chain approach for adaptation to Industry 4.0 technologies. The analysis of potential impacts of various emerging technologies on the value chain leads to an in depth understanding of innovative possibilities that are at the industry's disposal. Recognizing the potential application at unit levels is challenging from a general perspective of business activities.

Technology adoption rates are different across industries. Some technologies with a potential for greatly transforming industries are not yet utilized in some instances. Below is Figure 18 showing the percentage engagements of Industry 4.0 technologies across the manufacturing process in industrial sectors.

Figure 18 Adoption of 4IR Technologies Across Industries



Source: HfS Research, 2017⁵⁰

In this context, UNIDO is promoting a technology assessment of relevant economic sectors to support developing countries' efforts of industrial transformation. A thorough understanding of the technological trends is a reference point for predicting the sparks for innovation opportunities and business model development. To increase the effectiveness of UNIDO technical services, there is a potential to support in adapting and adopting these technologies in and across industrial sectors to enhance industrial transformation. Table 2 show current applications of 4IR technologies in different industrial economic sectors and their corresponding market trends.

Table 2 Current Applications and Market Trends for Emerging Technologies–Sectoral Analysis

		Agriculture	Energy	Manufacturing	Trade	Environment & Social
AI - Machine Learning	Applications	<ul style="list-style-type: none"> Plant breeding Automatic plant management Identification of biological anomalies Spatial planning and analysis of soil and weather conditions for precision-farming 	<ul style="list-style-type: none"> Track and optimize energy efficiency Model utility cost savings Provide recommendations for smart home Forecasts of power supply and demand 	<ul style="list-style-type: none"> Data exploration and interpretation Fleet management Developing and testing products Delivering connected equipment Cognitive analysis Process optimization 	<ul style="list-style-type: none"> Credit scoring using non-standard data Autonomous vehicles HR management -recruitment and talent matching Enhanced user experience Personal assistants in consumers' day-to-day activities 	<ul style="list-style-type: none"> Improving diagnostics Health trend analysis Epidemic outbreak predictions Intelligent vehicles Personalizing products and services
	Market Trends	<ul style="list-style-type: none"> Automation techniques in irrigation⁵¹ Robotics and digital farming Agriculture robots AI based sowing 	<ul style="list-style-type: none"> Leveraging data analytics Integration with IoT 	<ul style="list-style-type: none"> Integration with cloud computing AI enabled computer chips Edge computing Digitization 	<ul style="list-style-type: none"> Deep learning E-commerce Upgraded privacy policy Socio-economic models Neural networks Cybersecurity 	<ul style="list-style-type: none"> Predictive analytics Facial recognition Upgraded privacy policy Socio-economic models Cybersecurity
Drones	Applications	<ul style="list-style-type: none"> Monitor crops and soil conditions⁵² Cadastral management 	<ul style="list-style-type: none"> Maintenance of transmission networks Utilize radio signals to collect measurements of specific activities 	<ul style="list-style-type: none"> Aerial analysis of buildings and other infrastructure Cadastral management in mining sites 	<ul style="list-style-type: none"> Last mile delivery-autonomous delivery Access remote locations 	<ul style="list-style-type: none"> Delivery of drugs to remote areas Inspecting difficult-to-reach areas Cinematic production
	Market Trends	<ul style="list-style-type: none"> Image-based insight generation Integration with AI and sensors 	<ul style="list-style-type: none"> Testing solar powered broad bands drones 	<ul style="list-style-type: none"> Decreasing prices of drone components (e.g., sensors, batteries) Increase in drone investments Technological developments in artificial intelligence (AI) and analytics. 	<ul style="list-style-type: none"> Massive commercial market potential Drone data communication services Amplification of internet network signals Algorithm-driven autonomous drones Insurance for commercial operators 	<ul style="list-style-type: none"> Drone hardware commoditization Drone management and services value increases

		<i>Agriculture</i>	<i>Energy</i>	<i>Manufacturing</i>	<i>Trade</i>	<i>Environment & Social</i>
<i>Big Data/ IoT⁶¹</i>	<i>Applications</i>	<ul style="list-style-type: none"> • Telephone farming • E-extension • Inputs-as-service • Credit scoring farmers • * Internet-enabled irrigation systems • Monitor optimal grain storage and potential hazards in systems such as grain elevators • Remote telephone farming 	<ul style="list-style-type: none"> • Smart grids • Sale of solar power as utility/service through internet-enabled cookers and solar panels • Real time data analytics 	<ul style="list-style-type: none"> • Process optimization; • Specific market segmentation • Elimination of mass markets • Tracking of construction projects by linking drone pilots, site surveyors, construction site managers and BIM engineers. • Track production data 	<ul style="list-style-type: none"> • Shared economy • Financial inclusion • E-commerce • FinTech • Customer analytics • Real time data analytics • Harness the power of location data to make decisions⁵⁴ 	<ul style="list-style-type: none"> • Monitoring vaccines • Monitoring of medical deliveries • Real time data analytics • Reduced fuel consumption • Security infrastructures • Vehicle insurance
	<i>Market Trends</i>	<ul style="list-style-type: none"> • Digitization • Automation • Integration with AI – machine learning 	<ul style="list-style-type: none"> • Digitization • On demand services • Customized IoT data platforms 	<ul style="list-style-type: none"> • Digitization • Automation • Increase of quality to match quantity • Integration with AR and VR • Edge computing • Visual analytics 	<ul style="list-style-type: none"> • Digitization • On demand services • Customized IoT data platforms • Customer profile analytical models • Huge demands for data • Cybersecurity 	<ul style="list-style-type: none"> • Digitization • On demand services • Customized IoT data platforms • Privacy regulations • Demand for digital skills • Cybersecurity
<i>3D Printing</i>	<i>Applications</i>	<ul style="list-style-type: none"> • Locally fabricated agricultural machines and repair items/parts • Prototyping farming equipment • Creation of novel products • Replication of objects⁵⁵ 	<ul style="list-style-type: none"> • Locally fabricated energy machines and repair items/parts 	<ul style="list-style-type: none"> • Locally manufactured machinery parts • Elimination of the factory manufacturing model 	<ul style="list-style-type: none"> • Toll/contract manufacturing; community workshops 	<ul style="list-style-type: none"> • Printing prostheses for amputees and patient specific implants⁵⁵ • Sustainable indoor gardening
	<i>Market Trends</i>	<ul style="list-style-type: none"> • Shift from business centric models to customer centric models • Mass customization⁵⁷ • New markets for agricultural products 	<ul style="list-style-type: none"> • Polymers with flame-retardant properties • New metal materials • Increased demand for 3D printed circuit boards 	<ul style="list-style-type: none"> • Metal divergence • Elevated levels of sophistication in metal printing systems⁵⁸ • Innovation in binder jetting • Quality plastic printing • Shift from manufacturing knowledge to modelling • Metal material producers expand across AM value chain • Digitization 	<ul style="list-style-type: none"> • Development of high-performance thermos-plastics • The rise of composite materials • 3D printing graphene • Policy and regulation 	<ul style="list-style-type: none"> • Customization • Re-shoring and offshoring • The growth of elastomeric materials • New skills development • 3D printers for home-use • Increased isotopic printing opportunities⁵⁹

		Agriculture	Energy	Manufacturing	Trade	Environment & Social
Blockchain	Applications	<ul style="list-style-type: none"> • Food traceability system for international trade • Optimization of the Food Supply Chain • Peer-to-peer agricultural transactions and processing⁶⁰ • Agri-digital (Digital land registers of land titles of farmers, digital records of crop storage in warehouses) 	<ul style="list-style-type: none"> • Peer-to-peer energy transactions and processing • Wholesale electricity distribution • Peer-to-peer energy trading • Electricity data management • Commodity trading • Oil and gas resource exploration • Oil and gas resource storage and transportation • Refined resource management and sale 	<ul style="list-style-type: none"> • Information sharing in transport and logistics • Enhancing trace and track • Protecting and monetizing critical Intellectual Property • Safeguarding quality checks • Cybersecurity 	<ul style="list-style-type: none"> • ‘Smart contracting’ • Cryptocurrency-based transactions • Financial transaction platforms and systems • Smart appliances • Trade processing and settlement 	<ul style="list-style-type: none"> • Block chain-enabled platforms to share public health records • Trade transactions used by customs services to collect tax on imports/exports
	Market Trends	<ul style="list-style-type: none"> • Decentralized insurance applications. • Transparent digital food supply chains • Crop insurance 	<ul style="list-style-type: none"> • Integration with AI and IoT • Peer-to-peer energy markets • Use the Ethereum blockchain⁶¹ 	<ul style="list-style-type: none"> • Demands for block chain experts • Service supply chains • Interaction between machines • Blockchain integration with the Internet of Things (IoT) • Enabling machine-controlled maintenance • Advancing machines as a service • Digitization 	<ul style="list-style-type: none"> • Decentralized apps • The line between ICOS and equity financing is blurring • Regulatory activity is a double-edged sword — bad for ICOS, good for others • Top VCs (venture capitalists) are embracing tokens, moving from “block chain” to “crypto”⁶² • Security tokens are seeing increased investor interest • Cybersecurity 	<ul style="list-style-type: none"> • Regulatory scrutiny • Block chain as a service⁶³ • Decentralized social networking • Cybersecurity
Convergent Technologies	Applications	<ul style="list-style-type: none"> • Data collection for credit score – Farm-Drive • Connecting farmers and distributors-Crop Pro Insurance 	<ul style="list-style-type: none"> • Industrial symbiosis • Renewable energies 	<ul style="list-style-type: none"> • Circular economy • Industrial symbiosis • Edge computation and consumer devices • New business models for the business model of the internet⁶⁴ • More accurate mixed reality (AR) 	<ul style="list-style-type: none"> • Autonomous vehicles⁶⁵ • Nanotechnology⁶⁶ • Product-as-a-service (PaaS) • Airport security scanning • Pharmacy dispensary of medications • Monetize electrons 	<ul style="list-style-type: none"> • Car sharing⁶⁷ • Interface for digital identity • The catalyst for consumer IoT adoption (virtual agents and smart home appliances)
	Market Trends	<ul style="list-style-type: none"> • Digitization • Automation • Hybrid materials and devices 	<ul style="list-style-type: none"> • Edge computing • Clean renewable technologies⁶⁸ 	<ul style="list-style-type: none"> • Integration of technologies • Edge computing • Convergence • Digitization 	<ul style="list-style-type: none"> • Development of the 5G edge industry • Exponential technological innovations • Commoditization 	<ul style="list-style-type: none"> • Hybrid devices and materials

		Agriculture	Energy	Manufacturing	Trade	Environment & Social
Sensors, Visualization and Simulation	Applications	<ul style="list-style-type: none"> • Mini multi-spectral sensors attached to drones⁶⁹ • Collar with built-in movement sensors and microphones • Connected weather station • Remote sensors • Packaging sensors 	<ul style="list-style-type: none"> • Smart grid • Smart meters • Piezo-mechanical harvesting • Energy harvesting⁷⁰ • Energy storage • Power management • Inventory management in gas & air tanks • Oil/gas wellhead monitoring • Fuel and water storage tanks liquid level monitoring • Factory gas flow and metering applications 	<ul style="list-style-type: none"> • Machine condition monitoring • Accelerometer • Inventory management • Data collection on manufacturing operations and processes • Smart manufacturing equipment • Inspect and monitor work in progress interface with the manufacturing equipment • Self-monitoring of manufacturing by the manufacturing system's own computer⁷¹ 	<ul style="list-style-type: none"> • Fire detection or sprinkler systems • Transport-enabled sensing • Satellite observations 	<ul style="list-style-type: none"> • Water pollution source localization • Water quality monitoring systems • Pollution monitoring systems⁷² • Portable air quality sensors⁷³ • Transport-enabled sensing • Mobile application wireless sensors⁷⁴ • Satellite observations
	Market Trends	<ul style="list-style-type: none"> • Digitization • Automation⁷⁵ • Robust sensor designs 	<ul style="list-style-type: none"> • Digitization • Predictive modelling demand and generation response • Sensor data collection 	<ul style="list-style-type: none"> • Digitization • Agile manufacturing-intelligent manufacturing systems • Multi-sensor modules⁷⁶ • Robust sensor designs • Automation 	<ul style="list-style-type: none"> • Digitization • Multi-sensor modules 	<ul style="list-style-type: none"> • Digitization • Data visualization • Customer driven designs
Virtual Reality and Augmented Reality (AR & VR)	Applications	<ul style="list-style-type: none"> • Gathering and harvesting fish • Agriculture machinery design 	<ul style="list-style-type: none"> • Inspection, analysis and recognition of potential hazards • Communication during work on power plants 	<ul style="list-style-type: none"> • Repair and maintenance • Training and simulation • Preventing accidents and disruptions • Designing and prototyping • Inventory management 	<ul style="list-style-type: none"> • Workforce training and teaching • Design and visualization • Sales 	<ul style="list-style-type: none"> • Customer engagements • Virtual meetings
	Market Trends	<ul style="list-style-type: none"> • Aquaculture 	<ul style="list-style-type: none"> • Enhanced industrial safety 	<ul style="list-style-type: none"> • Visual Analytics • Integration with equipment 	<ul style="list-style-type: none"> • Real time employee instruction 	<ul style="list-style-type: none"> • Increased security • Better quality

Source: Author's own compilation based on literature review of references 50 to 76.

2.4 GMIS Actions for Convening Multi-Stakeholder Partnerships for 4IR

UNIDO and the Ministry of Energy and Industry of the UAE co-chair the GMIS initiative. The GMIS Organizing Committee, in collaboration with UNIDO, organizes multi-stakeholder dialogues on 4IR in different countries all over the world with the principal objective of expanding manufacturing capabilities of countries. GMIS Connect is the associated international roadshow programme which is strategically held in some of the world's leading manufacturing hubs, but also in emerging and developing countries.

ITM 2019 hosted one GMIS Connect roadshow, focusing on Mexico's landscape for 4IR. GMIS Connect is the starting point for engaging the local manufacturing community with local partners on trends, opportunities and challenges brought by 4IR at the country and regional level. Through connecting governments, local and international manufacturers, start-ups and SMEs, NGOs and academia, GMIS Connect events are a key component for gathering insights and shaping the discussions for the annual Global Manufacturing and Industrialisation Summit (GMIS).

The main objectives of GMIS Connect roadshows include:

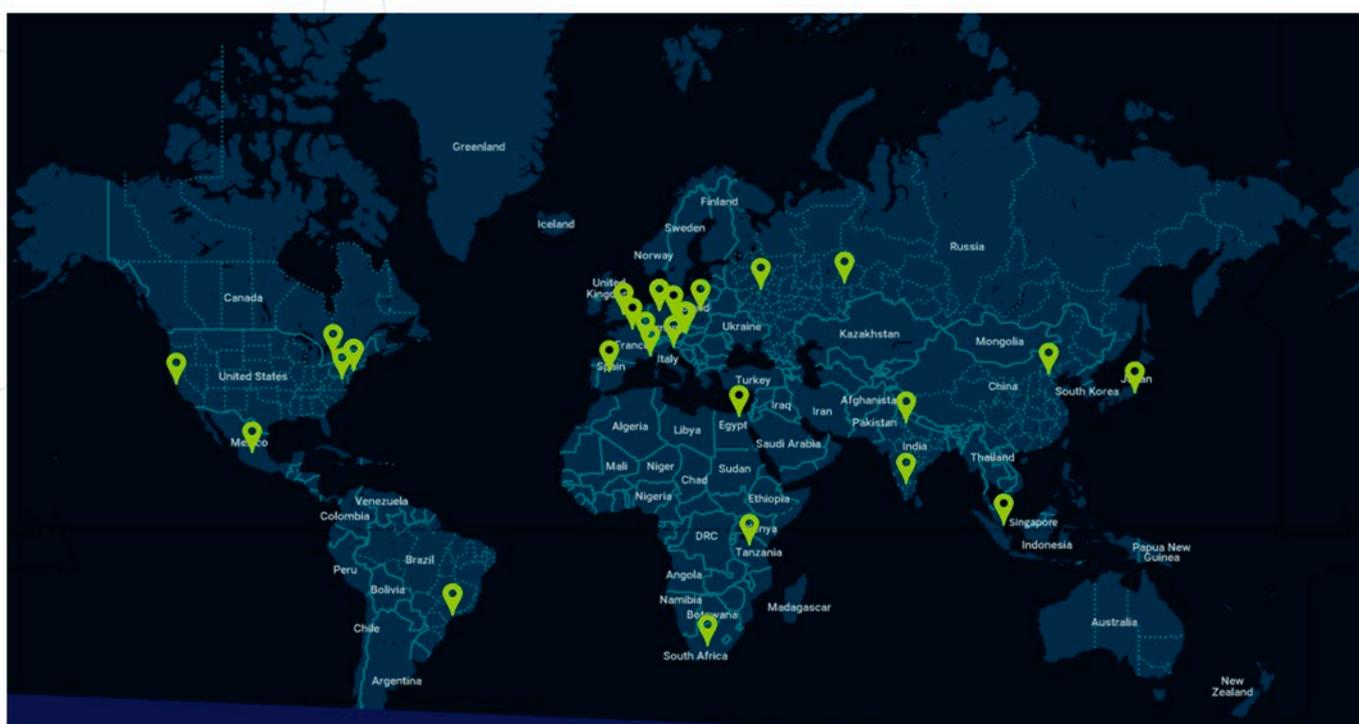
- To identify and engage with relevant speakers who can participate in the annual Summit and future events and gather insights that will feed the Summit agenda;
- To stimulate multi-stakeholder involvement to address challenges faced by the manufacturing sector and to identify solutions to support the SDGs;
- To capitalize on opportunities for innovation and creativity, and explore how industry stakeholders can develop mutually beneficial partnerships.
- To seek concrete outcomes in order to define the next steps necessary for embracing the Fourth Industrial Revolution.

GMIS Connect supports the entire spectrum of 4IR stakeholders in the host country with a platform to showcase latest innovations and build business partnerships. The hosting country's SMEs and private sector at large can prepare for new trends in manufacturing, learn and link to innovation, build business contacts and partnerships, and integrate in global and regional production networks. Additionally, government can inform participants of their industrial policies and programmes in view of new trends in manufacturing and orient policies towards Inclusive and Sustainable Industrial Development (ISID) and build partnerships with the private sector, international organizations and development agencies.

The first Summit took place in 2017 in Abu Dhabi, United Arab Emirates. The event was the world's first ever cross industry forum endorsing consensus points on the future of manufacturing focusing on 4IR and the SDGs, articulating the role of government, developing countries, workforce, climate action, smart cities and standards. The second Summit was held in Yekaterinburg, Russian Federation, in July 2019, elaborating upon the theme of "nature-inspired technologies" and the role of advanced manufacturing in achieving the SDGs.

GMIS has organized many Connect roadshows around the globe. In 2017 the events were held in Spain, Germany, Austria, United Kingdom and China. In 2018, the events were held in Germany, Canada, Switzerland, USA, Italy, France and Brazil. In 2019 GMIS Connect Roadshows were held in Egypt, Russia, China, Germany, and Mexico. Regional events like GMIS Connect Southern Africa were also organized in association with the Southern African Development Community (SADC); GIZ; NCPC-SA and the GMIS Organizing Committee. Representatives from most of SADC's 16 Member States took part. Also a regional event was conducted in Tanzania, held at the Headquarters of the East African Community (EAC), supported by GIZ and in association with EAC; the East African Business Community; East African Commission on Science and Technology; and the GMIS Organizing Committee. Participants from all six of EAC's Member Countries took part. Other GMIS events also took place in India and Singapore in 2019, as well as a side event during the 74th session of UNGA. Figure 19 summarizes GMIS Connect roadshows and the Summits, up to December 2019.

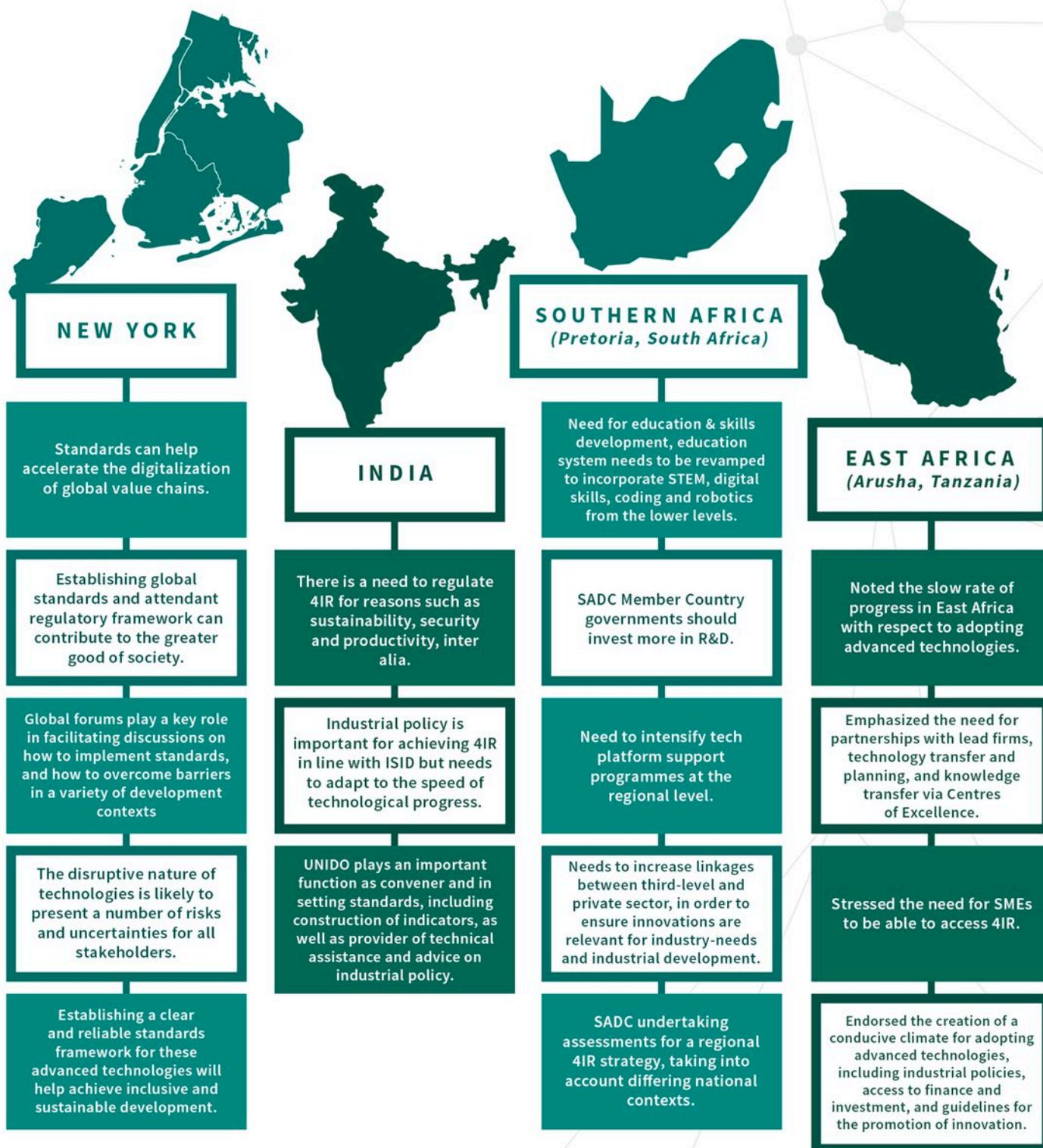
Figure 19 GMIS Around the World



Source: <https://www.gmisummit.com/roadshows/>

Several GMIS events in 2019 emphasized readiness for adaptation and adoption of emerging technologies. Amongst other things, the main issues participants raised at these events pertained to national and regional 4IR contexts, and in some cases, political declarations on 4IR have been signed. For example, at GMIS Connect East Africa, the East African Community adopted the "Arusha Resolutions on Adoption of Advanced Industrial Technologies in East Africa". Figure 20 shows a summary of the main takeaways from the GMIS Connect events held in 2019, besides the one in Mexico.

Figure 20 2019 GMIS Connect Roadshows Takeaways



Source: Author's own compilation based on UNIDO Presentation during Briefing to Member States on GMIS, Vienna (January 2020) by Mr. Bernardo Calzadilla Sarmiento.

CHAPTER 3. UNIDO AND GMIS ACTIONS AT ITM 2019

3.1 The Industrial Transformation Mexico 2019

The Industrial Transformation Mexico (ITM) is a strategic platform where manufacturers, technology providers and opinion leaders exchange ideas and best practices, build new networks and capitalize on opportunities for innovation. The platform introduces companies to cutting-edge 4IR technology concepts and market trends, such as smart manufacturing, smart supply chain management and talent development. ITM offers a broad range of industrial solutions for aerospace, automotive, electronics, food and beverage, pharmaceutical and chemical sectors, among others, thus it was named a leading event of 4IR in Mexico, and a key event for the Latin-American business community.



Opening Ceremony of ITM 2019 inaugurated by Diego Sinhue, Governor of Guanajuato

The first edition of Industrial Transformation Mexico, the Latin-American version of Germany's Hannover Messe, was successfully held in the city of Leon, Guanajuato, Mexico. The event took place from October 9-11, 2019. The opening ceremony included Deutsche Messe Board Chairman, Jochen Keckler; Managing Director of Hannover Fairs Mexico, Bernd Rohde; the Governor of Guanajuato, Diego Sinhue Rodríguez Vallejo; Secretary of Economy, Graciela Márquez Colín; President of the Mexican Confederation of Industrial Chambers, Francisco Cervantes Díaz; BDI President, Dieter Kempf; Leon mayor, Héctor López Santillana; ATMS President, Arturo Lozano; Siemens Global CEO, Joe Kaeser; A3 President, Jeff Burnstein; President and CEO of Schneider Electric Mexico and Central America, Enrique González Haas; and GIZ Innovation and Digital Policy Managing Director, Stefan Schnorr.



Graciela Márquez Colín, Secretary of Economy; **Diego Sinhue Rodríguez Vallejo**, Governor of Guanajuato; **Bernd Rohde**, Director General of Hannover Fairs Mexico (from left to right).

Mr. Diego Sinhue Rodríguez Vallejo gave opening remarks articulating that ITM is a launchpad that will allow Guanajuato and Mexico to leapfrog toward a better future by moving from manufacturing to innovation centred on Industry 4.0, through designing the future utilizing technology as a driver for innovation. He pointed out that 4IR is the key in Mexico and Latin-American for the future adaptation to new technologies.

The event was composed of the exhibition area, conferences and an extensive educational programme, all linked by the general issues of digital transformation in Mexico and intelligent manufacturing. The exhibition area presented four main categories: Machine-Tool/ATMS, Automation, Robotization and Power Transmission; Digital Manufacturing and ICT; Intelligent logistics and areas for live demonstrations and individual consultations. The space served the following industrial sectors; aerospace, automotive, electronics, food and beverages, metallurgy, steel and chemical packaging and processing. Figure 21 summarises the impact areas at ITM 2019.

Figure 21 Impact Areas at ITM 2019 ¹

EXHIBITION CATEGORIES



RESEARCH INSTITUTIONS



AUTOMATION,
ROBOTIZATION AND DRIVE



DIGITAL FACTORY



ADDITIVE MANUFACTURING



SMART LOGISTICS



POWER SOLUTIONS



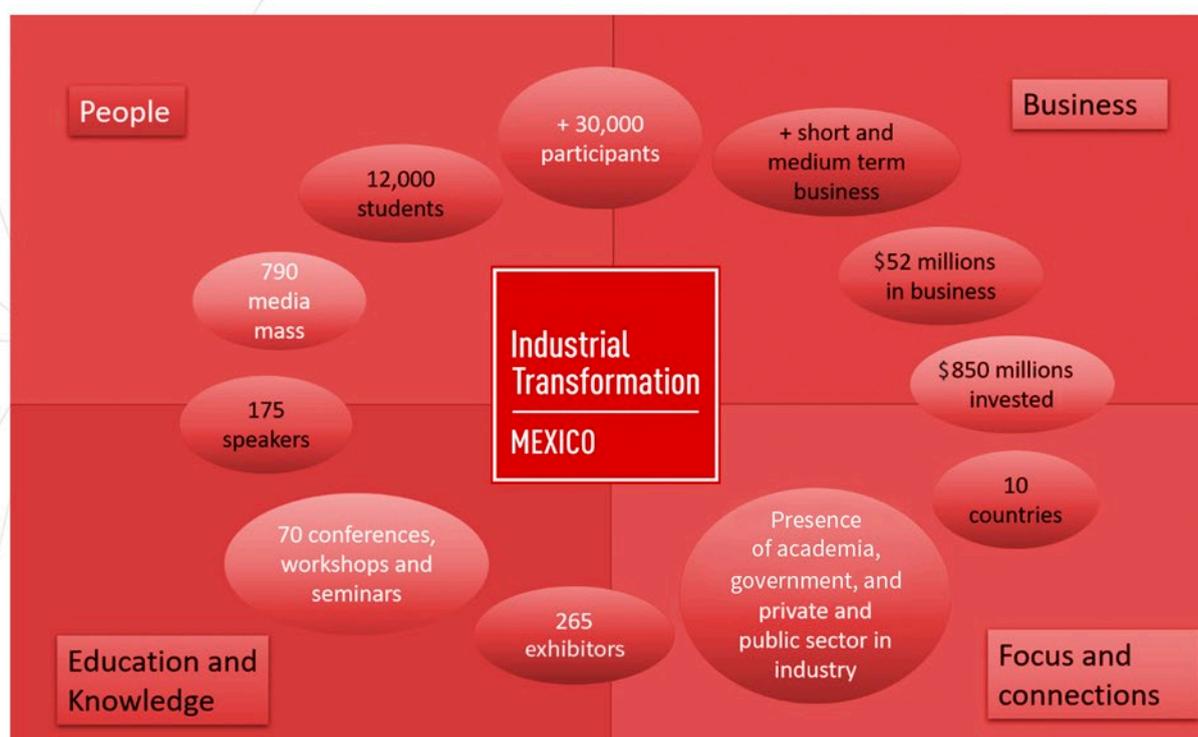
METALWORKING



GOVERNMENT

More than 10,000 specialists participated from various backgrounds of expertise and 200 leaders in the private and public sectors. About 30,000 people attended the event over the 3 days of the exhibition; among which half were professionals, approximately 12,000 students, and 790 media professionals. During the event 70 conferences, seminars and workshops were held showcasing 175 speakers. The ITM organizers invested 850 million US Dollars in the event, 52 million US Dollars in business in situ and short and medium term business.

Figure 22 Summary of ITM 2019 Participants



Source: *Industrial Transformation Mexico 2019* <https://industrialtransformation.mx/en/>

There were 265 exhibitors covering 18,000 square meters, with 25% of exhibitors from Mexico and 75% from the rest of the world. The top 10 countries that participated were Germany, Argentina, China, Korea, Spain, USA, France, Italy, Japan and Mexico. ITM 2019 became the first 4IR educational platform dedicated to increasing and promoting the inclusion of women in the 4IR.

3.2 UNIDO – GMIS Thematic Panels Programme, Interventions and Key Salient Points

UNIDO, in collaboration with the GMIS Organizing Committee, organized a series of thematic panels during the ITM 2019 fair. The main topics discussed were on strategic approaches to the CE, innovation and quality infrastructure to broaden market access and integration into global value chains. All this had a core focus on adaptation and transition to 4IR, as well as the implementation of 17 SDGs to accelerate industrial transformation. Panellists from government, academia, private and business sectors were invited for discussion based on areas of expertise in order to identify the main challenges and opportunities brought about by the 4IR, particularly for Mexico.



Namir Hourani, Managing Director of GMIS

GMIS Connect Mexico Session - Industry 4.0: Maximising the Adoption of 4IR Technology

The GMIS Connect Mexico session started with the introduction to GMIS's vision, objectives and initiatives, followed by a keynote presentation and a panel session focusing on increasing the adoption of 4IR technologies; and best international practice adopted for local conditions.

“The Fourth Industrial Revolution is affecting trade at every level. Only by working together, as a global community can we achieve the true potential of this transformation. The GMIS Connect roadshow in Mexico highlighted the energy and drive in Mexico to embrace all that the 4IR has to offer. As such, Mexico can become a pioneer of the digital revolution, bringing positive change to the industry and economic prosperity as a result.”

Keynote Speech

“The dawn of the 4IR marks a new chapter in the global economy and it is vital that we put the foundations in place to ensure it reaches its full potential. A key part of this is ensuring international, regional and local trade relationships are strong, fair and effective, allowing the entire value chain to thrive. This will only be made possible by open and frank discussion, and a global consensus on behaviour and objectives. Smart industrialization is pushing towards globalization in search for new market opportunities concurrently offering great value to customers.”

The moderator for this session was **Carlos Zegarra**, Partner – Management Consulting Leader, PwC Mexico; and the panelists were: **Prof. David Romero**, Advanced Manufacturing Research Group, Center for Innovation in Design and Technology, School of Engineering and Sciences, Tecnológico de Monterrey; **Felipe Sandoval**, General Manager, SAFRAN Aerosystems Operations, President, FEMIA-Mexican Federation of Aerospace Industry; **Manuel Sandoval-Ríos**, CEO, ProMx, and Founding Partner, iKnoware; and **Dr. Cecilio López**, ISC Senior Director, Honeywell Aerospace de Mexico.



Carlos Zegarra, Partner – Management Consulting Leader, PwC Mexico

The panel delivered valuable insights on how global manufacturing giants are in the process of adopting 4IR technologies, such as IoT, Robotics and AI across their various operations. The adoption process requires an uphaul of education and skills development for existing and future workforce, as well as the machines and factories where this workforce will apply their new skills.

Emerging technologies are enabling industrial transformation to cope with changing consumer expectations. This technological push includes inter alia cloud platforms, smart sensors, mobile and tracking solutions, connected cyber physical systems, computer processing power, intelligent algorithms and IoT. External drivers that transform business activities comprise of customer expectations, increased supply chain complexity and integration of partners, digital lifestyle or social web, service and cost pressure and local and global regulatory requirements.

The paradigm shift to customer centric models requires a collaborative supply chain that captures and creates value as expected to increase market share. The smart factory of the future is characterized by flexible and integrated value chains, virtualized processes and virtualized customer interface with industry collaboration as key value driver to attain efficiency within the digital ecosystem.



The panel acknowledged that changing customer expectations, digital technologies and IoT, growth and cost saving opportunities are shaping the future of value chains. New business models are developing with a great push for digitalization, data analytics and action as core competency. It is important that governments and the private sector continuously define programmes and initiatives aimed at increasing the skilled talent pool to meet 4IR requirements in order to assure sustainability of employment levels given the evolution of technology.

The session continued with three UNIDO thematic panels. The discussions focused on industry as an engine of development and the 2030 Agenda for Sustainable Development, towards a green Industry 4.0, and facilitating market access and quality infrastructure.



UNIDO Panel I. Industry as an engine of development and the Agenda 2030 for Sustainable Development

Keynote Speech

“Industry is a dynamic engine of prosperity and collective well-being. No country has achieved a high level of economic and social development without developing an advanced industrial sector. Too often, these transformative structural changes have been accompanied by environmental degradation and increased social inequalities. In order to ensure an equitable distribution of the economic benefits of industrialization, a sound environmental and social framework must be established.”

Coordinator of UNIDO Panel 1, Ramiro Magaña
National Coordinator of UNIDO Mexico

UNIDO’s vision of *"Inclusive and Sustainable Industrial Development"* aims to address the multidimensional causes of poverty by creating shared prosperity, advancing economic competitiveness while preserving the environment. The notion of ISID focuses on Sustainable Development Goal 9 of the Agenda 2030 for Sustainable Development, aimed at building resilient infrastructure, promoting inclusive and sustainable industrialization, fostering innovation, economic growth and creating decent employment.

This international strategic framework is of importance for Mexico given the context of low growth and relative abandonment of industrialization policies for more than three decades. This has weakened the country’s productive capacity. Although unemployment figures have been relatively low, they conceal problems in the country’s labour market such as informality, underemployment, precariousness, low wages, low productivity and segmentation and a decrease in the quality of education at all levels.

The Agenda 2030, economic growth and industrialization positioned a fundamental vector for the development of countries, as a prosperous, high quality, sustainable and equitable way of life is attainable through the transformation of economic structures, increased productivity and employment, decent work, quality education, as well as innovation and improvement of infrastructure.

In this context, UNIDO’s extensive knowledge and experience in supporting countries in their sustainable industrialization efforts make it an imperative reference for the implementation of all industry-related aspects, not only regarding SDG 9, but all the 17 SDGs, as well as for monitoring and reviewing the progress of industrial and economic issues in general, in their respective advances in the framework of Agenda 2030.

Panelist Section

In Mexico, in recent years, large investments have been made in transportation, clean energy, information technology, and expansion of cellular telephone access and the goal of universal Internet access. The advance of the aeronautical and automotive industries has attracted international talent and in turn has increased the economic progress of the agricultural industry and production of metal products. This has implied the expansion of local airports, the improvement of road links, the optimization of railways and the logistics network in the center of the country.

Discussion: *Will this dynamic eventually affect population development issues such as reduction of inequalities, gender equality, health, decent work, quality education, etc.? How?*

“For a complete industrial transformation, all regions in the country must be developed. All sectors must be aligned for the system to work. Sustainability begins in-house, starting from separating trash and that is done in industrial parks; responsible authorities set up green areas and provide transport for the workers, also encouraging the use of bicycles. This consciousness about SDGs must be implemented everywhere, be it in schools or households.”

“Today almost half of the population of Mexico lives in poverty-stricken conditions. This problem requires ethical companies that provide a motor for economic development. In this central part of the country, there are great opportunities. A transition has been achieved from an agricultural region to a manufacturing one.”



Claudia Ávila Connelly, General Director,
Mexican Association of Industrial Parks (AMPIP)



Sergio Ponce, Director, Mexico-United
States Chamber of Commerce Economic
Growth and Social Inequalities

“The solution is to integrate all social groups, including minorities, such as indigenous communities working in an efficient and ethical way to provide food for all the people. There is a lack of entrepreneurial and social education to take Mexico from a maquiladora country to a manufacturing country. A transition into the 4IR is essential for industrial development.”

“The State of Guanajuato has always been a relevant actor within Mexico, since the mining industry was established during the colonial era, then agricultural activity, up to the industrialization that is occurring at present. Guanajuato is experiencing massive urbanization, and this has been unsustainable.”

“Urbanization in general has been the most disruptive social phenomenon of the 21st century. Environmental transformation requires land-use planning capable of reducing the negative impact on ecosystems and the number of accidents in companies. Here is the major role of industry and its planning fundamentals in the rearrangement of the earth.”

The Industry for Agenda 2030

Transformation is about the type of citizens produced by educational institutions. Are academic institutions equipping individuals according to the industry needs or according to the 2030 agenda? The workforce must be prepared to adapt to change and be aware of technological environment changes.



Rolando López Saldaña, General Secretary, National College of Technical Professional Education

“Looking into psycho-social development of the people who work in industry, work-life balance and work environment is of paramount importance because those are the basis of development within industry. This is consistent with SDG 16 which promotes peace, justice and solid institutions; inter alia promoting collaboration to work with all employees in order to tackle corruption, cyber-crimes, crimes within companies, harassment, gender violence, and addressing gender equality, considering how education is progressing and industry indications for future needs. Additionally, the industry must assist in shaping public policies to work on issues of plastic pollution reduction. Industry should lead us towards the future.”

The panelists elaborated on the theme of Industry 4.0 in A2030:

“It is obvious that SDG9 has an impact as it moves towards all other targets. In that sense, Mexico in recent decades has made several investments in transport, clean energy, information technology, expansion of cellular telephone access, and the goal of universal access to the internet for all citizens.”



Fidel García Granados
Undersecretary of Land Use Planning and Natural Resources Management, Ministry of Natural Resources and Land Use Planning of Guanajuato State. Economic Growth, Environment and Public Health

“Economic development and professional technical education must equip this generation with knowledge of these issues. Innovation can detonate the country’s regional economy and develop a social and CE. The generation of poles of development throughout the national territory could spark the formation of human capital in a sustainable manner including environmental sustainability. Many national priority projects are about to start, and those projects will conclude with the 2030 agenda for social, economic and industrial development.”



Arturo Gómez Shuster,
Former Representative, United Nations Volunteers

Open Session for Questions and Answers

During the open session for Questions and Answers, two main questions were raised during the first panel, highlighting the point of whether the 4IR prepares the young people to continue working in maquiladoras or to become innovators; and how can Industry 4.0 technologies be applied for improvement in industries to benefit all as per Agenda 2030.

In response to these questions, an example of 3D viewer technology in the countryside was given. The great challenge is how to provide this new technology for social development.

Another point mentioned was to quickly understand and adapt to these exponential technological advancements accordingly. Public policy decisions must be made on a long-term basis.



There is a need to reconsider and check for alternative solutions to take advantage of opportunities. Industrial development plans, for example, location of new industrial parks must consider transportation, toxic waste management and communication with academia since the students of today will be the workforce for tomorrow.

Educational training should be geared towards producing a relevant skilled labour force to the industry. Higher education institutions need to enforce development plans such as formation of groups of young people that have a strong desire for innovation, creative development and entrepreneurship within technical training fields. Meanwhile, students should be very innovative and must develop a problem-solving attitude in different areas of expertise. The question of what technologies to apply in industrial parks or various development sectors responds to identified needs and available technologies.

First Panel Highlights

Agenda 2030 can be accelerated by industry through formulation of alliances and partnerships among and between stakeholders, that is, academic institutions, research centres, industrial corporations and government authorities. Academic institutes should produce complements of critical skills needed for industrial transformation and mould innovation capabilities in youths. Entrepreneurial skills development is key to addressing challenges and needs thereby bridging the inequality gap.

UNIDO Panel 2. Moving towards a Green World through Industry 4.0

Keynote Speech

This panel addressed the two most important issues of the industry in the 21st century, Industry 4.0 and the CE.

“Consumers are the promoters of industrial development. UNIDO fervently believe that there is not going to be an industry in the world that does adopt/ apply CE concepts, as this will be the engine of industry survival. The time of producing, using and throwing away is in the past; now it is time to recover, renew, recycle and reuse.”



*Coordinator of UNIDO Panel 2
Guillermo Castellá, Representative for Mexico
and Director for Central America UNIDO Mexico*

First Section

In order to safeguard the environment, there are two major themes: industry 4.0 and the circular economy.

Discussion: *How does Industry 4.0 and the circular economy concept impact the Mexican industry, from the point of view of their area of performance and knowledge?*



Cristina Cortinas, General Director,
Cortinas-Cortinas A.C.

“There are places in Mexico, such as the Sierra Gorda of the state of Querétaro that are basically still undergoing the Second Industrial Revolution, but at the same time there are areas of international competitiveness with great advances in education and technology in the same state of Querétaro, which demonstrate the existing regional contrasts in Mexico. Therefore, the transition to Industry 4.0 is a great challenge for the country. The CE will make a great contribution to Industry 4.0, since it will help to trigger production chains, even in those areas that are being especially affected by climate change, such as agriculture.”

“The CE and Industry 4.0 are important concepts. The CE is the synthesis of all economies, and this means taking efficiency to the limit in a world where resources are finite. The technological advances are dazzling, though onerous. For instance, applying these technologies in Guanajuato would require three times the amount of energy currently used. Water is another case; a better management of resources will be needed. Guanajuato has a low resource capacity at present.”



Federico Arce,
Director, Implementation
for Development Agency



Germán Enríquez Flores, Expert,
Tecnológico de Monterrey

“Learning from the past revolutions, there was no knowledge of environmental impact, but general awareness of these considerations has started to increase in recent years. Industry 4.0 is the key, since it is capable of symbiosis with productivity and the generation of alliances to process knowledge. This demonstrates an anchor point with SDG 17 of the Agenda 2030 for a sustainable development. In addition, Industry 4.0 is a means for better management of natural resources and a greener world.”

“Energy efficiency is the answer on the consumption side. It is the most cost-effective measure to meet our climate goals. An example of this is renewable energy. Comfort and lack of awareness are problems for energy efficiency. Energy efficiency does not prohibit comfort. Time-of-use and behavioural change are the key to uniting comfort and energy efficiency in both the urban and industrial sectors. And this awareness of efficient use of energy is one of the keys for a smooth transition to Industry 4.0.”



Miguel Aké, *Technical Director, Nopalmex*



Noé Villegas Alcántar, *Director of Energy Management, National Commission for the Efficient Use of Energy (CONUEE)*

“Two important factors for growth, economic development and equitable distribution of resources are education and research. Linking the needs of industry with schooling, and vice versa, will enable a transition towards Industry 4.0. At Nopalmex, the concept of CE is already being applied. Nopalmex Biomass generates electricity and biogas. The best energy is not used, the effective use of time allows us to optimize energy. Nopalmex has two plants working to generate energy from waste such as nopal and avocado, without generating pollution. One more issue to consider, is the lack of equitable distribution, despite there being technological progress in Mexico, there is still poverty, and this continues to cause a high rate of inequality.”

Second Section

How should the application of the concepts of circular economy or the efficient use of resources or end-of-pipe solutions be promoted in Mexican society, in its communities or in its states?

Panellists highlighted various opinions on the application of the CE concept. Since past revolutions were not green, the challenge for the 4IR is whether it will be able to operate in a way that halts environmental degradation and climate change, prevent the disappearance of subspecies, or the loss of biodiversity.

Industry 4.0 and the CE together represent a great opportunity in terms of civilization. It is not only maximizing the uses of technological efficiency in the industry but extending it to the green laboratory. Many of the technologies applied in factories in recent years are solving problems of efficient use of resources, leading to the introduction of new materials and new products.

Both in the CE and nature there is no such thing as garbage or waste. Garbage is a design error. It is crucial to define how to harmonize the natural environment and industry, apply the design and move from better designs to generate energy efficiency, better goods and services without damaging the natural environment.

Nopalmex is an example of a circular economy company; everything is reused and has new value. In the reuse process, heat energy is generated which can replace LPG, natural gas and generate fuel for vehicles. These projects are socially sustainable because they create jobs, economically desirable because they are profitable, and environmentally friendly because the entire value chain does not harm the environment.

There is a great opportunity to promote Industry 4.0 through improved circular concept designs. The CE principles can be more effective if designed by academic institutions in collaboration with the industry. Pilot projects should be implemented in communities and circular concepts be utilized to address the identified challenges.



A central concern found regarding Industry 4.0 is that in the next 30 years, 50% of the work base will disappear, "as robots do not: eat, have rights, reproduce or own homes." So, what will happen with all this job displacement; is it going to grow the demand for food and resources? A strategy should be formulated to translate the new model of living for the future.

The end of pipe solutions replaced larger tubes which released emissions into the environment with efficient filters. This was an improvement in the use of fossil fuels, and cleaner fuels are used currently more than in the past. The concern to stop industrial production to achieve climate targets on emissions is inevitable, thus production in industry should advance with technology and energy efficiency to accelerate industrial development.

Third Section

Is Mexico ready to adopt the concept of Industry 4.0? Is Mexico ready to adapt and apply circular economy concepts? What should be done to generate the necessary conditions to achieve it?

Considering what happened in the preceding industrial revolutions, it is not about being ready. The developing world was not ready and that created a large inequality gap. There is capacity to achieve Industry 4.0 transformation if information becomes accessible and if there is willingness to collaborate as articulated by the SDG17, which deals with alliances for Global Partnership. It sounds trivial, but as human beings, it is time to co-operate and share best practices and view the world beyond being competitive.

Mexico requires a holistic strategy to adopt CE principles. Industry 4.0 provides a great opportunity to apply the CE much faster from the private sector. The global CE movement under Industry 4.0 has many projects that are being developed and there is a synergy for Mexico. All the projects implemented must have a logical and strategic structure for the country goals to be achieved.

The transition to Industry 4.0 requires universities and industries to form a partnership. Academic institutions and industries should be equipped for great opportunities. New jobs are being created and new technologies must be adopted. Academia must generate knowledge applicable to industrial processes. Duality between education and industry is undoubtedly the way to achieve it. Education must be strong at all levels providing an opportunity for the Mexican talent pool to develop and increase the country's industrialization potential.

Open Session for Questions and Answers

The audience expressed concerns about circumstances under which the society can request ecological education in private and government schools and how technologies are applicable in the countryside of Mexico, how technologies can be used on expired foods to avoid waste and in the agricultural sector.

The response given centered on the importance of establishing effective communication lines between education and society to bridge the gap between the stakeholders to enhance materialization and application of initiatives.



Producers are obliged to channel their products to the most vulnerable groups in need of food. One fact is that everything used will become waste, and that is where all the technologies under discussion here come in: transformation, soil improvers, and anaerobic bio-digestion to produce electricity, among others. The previous industrial revolutions moved people from the countryside towards the cities. Industry 4.0 is unique in that it opens up the opportunity to re-transfer technology back to the countryside and mobilize a large amount of population so that resources are made available to accelerate industrial transformation.

The theme is education and sharing knowledge. Environmental education has been migrating towards sustainable development, as the lack of resources such as water are often consequences of desertification, because there are rivers that are affected. It is not always about whether the know-how about trees exists or not, it's about having systemic thinking and that's a responsibility for all.

Industry 4.0 is unique in that it opens the opportunity to re-transfer technology back to the countryside and mobilize a large amount of population so that resources are made available to accelerate industrial transformation.

Second Panel Highlights

The application of the CE concepts increases the efficient use of scarce natural resources. Emerging technologies are essential in tackling climate change problems. Industry 4.0 is unique as it connects the world through the Internet of Things (IoT). Education systems must be strong enough to nurture a multi-skilled generation that can drive industrialization through innovation and entrepreneurship initiatives.

UNIDO Panel 3. Facilitation of Markets Access and Quality Infrastructure

Keynote Speech

“In the Fourth Industrial Revolution, the consumer is king and is more informed about products. Information is generated instantly allowing opportunities for quality infrastructure (QI) systems associated with emerging technologies. QI is a facilitator of innovation so the systems must be reinvented to transform not only the industry but also the way of thinking in the traditional systems at present. Two fundamental issues concerning the application of Industry 4.0 are: competitiveness of standards and quality assurance, especially for countries such as Mexico, and how to support Small and Medium Enterprises (SMEs) to increase their competitiveness through new technologies in order to access new markets.”



*Coordinator of UNIDO Panel 3,
Alejandro Rivera
Industrial Development Officer, Department
of Trade, Investment and Innovation, UNIDO*

First Section

What implications will the application of Industry 4.0 have on compliance with standards and quality assurance processes in Mexico?



Martha Mejía, Technical Director of the Mexican Entity for Accreditation

“Accreditation is fundamental for the alignment with the normative framework of national and international standards. The Mexican Entity for Accreditation (EMA) evaluates the third bodies that certify products, systems, laboratories and inspections from the regulatory point of view. There are large standards boards in Mexico for all industrial sectors. However, many of these standards require immediate review, because the evaluation of a product certification requires equipment or instruments that are not aligned to the new technology, which hinders the process. In preparation for the future, for example, recently, a new standard for Industry 4.0 was created, and a voluntary consumer protection for e-commerce should be formulated for users to have the confidence of using e-commerce platforms.”

Challenges for SMEs

“Most of Mexico is made up of SMEs that are in Industry 2.0. Public policy demands of the future shows a change of era, in which the best way is to adapt to the changes brought about by new technologies. Mexico's great challenge is informality; 50% of companies are in informal. First, the SMEs are still more informal and moreover operating in the Second and Third Industrial Revolutions hence preparing them for the 4IR transition is a huge challenge.”

“Artisanal and informal processes of SMEs must move from standardized processes to certified processes. Today the issue of certification must be a factor of competitiveness, and certification not only of companies but certification of workers themselves, that is the direction that SMEs should consider.”



Ramón Alfaro Gómez, General Director of Economy of León, Guanajuato, Mexico

Entrepreneurs need assistance, they need financing systems for micro, small and medium enterprises. A strategy should be formulated to boost collaborations between the suppliers and competitors. An understanding of the consumer market is more relevant than ever in order to build a stronger and more competitive industry.

“Agenda 2030 has 17 goals. The emphasis is on SDG 9 industry, Innovation and Infrastructure. SDGs are interlinked to each other, the industry can boost economic growth, eliminate hunger and impact on climate change at the same time. The consumer determines quality. Quality is the essence of competitiveness and processing. If a company is competitive it captures value, in the process creating employment and there begins the relationship with SDGs. Quality infrastructure and sustainable development are part of competitiveness. Quality monitoring is the country's responsibility. Certification and accreditation mechanisms are needed to prompt development of quality products.”



Guillermo Castellá, Representative for Mexico and Director for Central América, UNIDO Mexico

“One of the greatest opportunities from an academic point of view is postgraduate training. The 4IR is concerned with training professionals who will apply their knowledge to invent new techniques. A challenge for a researcher is how to obtain a product that has enough characteristics to reach standards and how to generate enough knowledge to attain a correct standardization measure. Product life cycles are now very short. Buzzwords like Industry 4.0, innovation, sustainability and green economy are marketing tools. It is crucial to establish mechanisms for quality infrastructure which can be evaluated in order to use a common nomenclature. Academia and research in this generation ought to gain enough metrics to define whether or not a product is satisfactory for the intended purpose.”

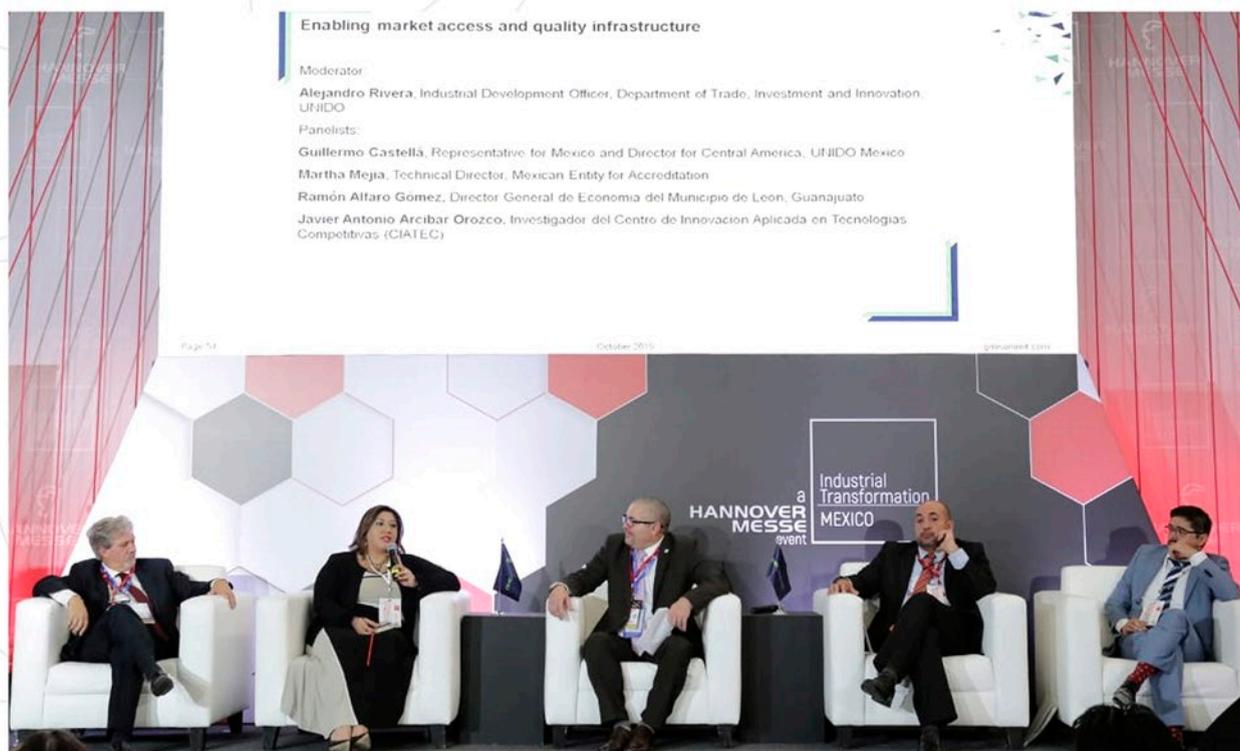


Javier Antonio Arcibar Orozco,
*Researcher of the Applied
Innovation in Competitive
Technologies Center*

Second Section

How are we addressing the future and what are the work strategies, or sector strategies that we have in mind to face these challenges?

The panelists emphasized the importance of systematic dynamism in quality infrastructure to cope with the exponential changes brought forth by emerging technologies. For instance, the diffusion of technology in Germany was very slow, because the quality infrastructure was not ready. This indicates that the lack of quality infrastructure is an obstacle to the development of innovation and appropriation of new technologies. It is necessary to create multidisciplinary groups that converge in their competences to define standards associated with new technologies.



A question raised in this section was how the public and industrial sector could collaborate with the accreditation bodies to improve the position of Mexico on adoption of Industry 4.0 technologies for gaining access to new markets. For QI development, main actors should be defined, norms established, standards and compliance entities and measurements are required to allow the declaration of quality of products tested and verified.

Consumers should define the product or service through interpreting product quality and avoid basing purchase decisions solely on price. To this end, academia is involved to inculcate the concepts of standards, methodologies, metrology, quality control and quality infrastructure. EMA is immersed in all sectors, and each sector has its own standards that ensure the safeguarding of the entire system, care of the environment, customer service, product safety. The challenge is to keep this entire system at the forefront, to remain competitive and obtain access to more markets.

Third Panel Highlights

Quality infrastructure drives modernization in the business world at the same time establishing market access for local SMEs to operate on a global scale. Participation on a global scale means a high level of competitiveness. Competitiveness is determined by compliance with international quality standards and this increases the opportunities for sustainable business operations.

3.3 Other UNIDO Activities at ITM 2019

UNIDO's participation at the Industrial Transformation Mexico was complemented by an exhibition booth over the duration of the event. Representatives in the booth were from UNIDO's Mexico Regional Office who informed participants about UNIDO's strategic objectives, service trends in relation to Agenda 2030 for Sustainable Development, as well as its vision on the 17 SDGs.

UNIDO had a unique opportunity to increase awareness on its mandate of Inclusive and Sustainable Industrial Development (ISID). There was an anticipation of partnerships and collaboration between government, academia, private industry and civil society.

The stand was of great interest to many with an average of about 800 visitors per day. Among the attendees were students, businessmen, entrepreneurs, representatives of government and academia, as well as civil society. The main questions that the audience raised were related to the 17 SDGs. Participants were keen to understand UNIDO operations and contribution to the Agenda 2030. Business organizations were seeking potential collaborations and ways to effectively integrate the SDGs into their operational activities.



An in-depth understanding of the work done by UNIDO in Mexico was a point of reference for many enterprises to support industrial development in their respective communities, and cities. Considering that all SDGs are interlinked, businesses consulted on the application of CE concepts and principles during ITM 2019. Participants were interested in the support UNIDO offers in creating innovation hubs and science and technology parks.

Moreover, the Representative for Mexico and Director for UNIDO Mexico-Central America, Mr Guillermo Castellá, delivered a press briefing to the City of León, Guanajuato. The “Mexican Industrial Reporter” conducted the interview. Guillermo Castellá emphasized the UNIDO approach to Inclusive and Sustainable Industrial Development (ISID), operational and strategic objectives, the role of UNIDO in safeguarding the environment, and creating shared prosperity for all making sure that none are left behind. He also gave illustrations of the applications of these strategies relating to the project work of UNIDO moving towards Industry 4.0; technology adaptation and adoption; and CE concepts, linking the 17 SDGs in Mexico and the Central America region. Another important aspect mentioned was the relationship of industry and its environmental effects from different points of view, public policies and product quality⁷⁷.



Following intensive interactions with national stakeholders and international partners along the different activities at ITM 2019, two concrete results were achieved. Firstly, new lines of cooperation of UNIDO with the industrial chambers were identified – within the framework of the 2018 Memorandum of Understanding (MoU) signed between CONCAMIN and UNIDO, in particular:

- a)** To further develop a proposal to assist the automotive sector for strengthening their adoption of Industry 4.0 by improving quality infrastructure and supplier's development services involving several Mexican States; and
- b)** To develop a new proposal to facilitate technology transfer, investment through the setup of an advanced training/ skilling centre for embracing Industry 4.0 through the shoe and leather manufacturing sector in Guanajuato State.

Secondly, multi-stakeholder partnerships were explored in order to facilitate technical training demand for new skills; the transfer of new technologies; and leveraging investment on required infrastructure for the digital transformation of local SMEs. Interactions with international institutions like Fraunhofer IPK, ENPACT, as well as locals like Universidad La Salle, Monterrey Technological Institute (ITESM), National Polytechnic Institute (IPN), among others, were conducted.

CHAPTER 4. UNIDO AND ITM 2019: IMPLICATIONS AND THE WAY FORWARD

The rising capabilities and affordability of 4IR technologies are bringing the opportunities discussed throughout this publication closer. However, while these technologies have the potential to deliver numerous economic, environmental and social benefits and to contribute to addressing some of the most pressing global challenges, it is important to ensure that those benefits are evenly distributed. If not adequately managed, the 4IR could contribute to preserve or even aggravate the existing inequalities, especially among vulnerable groups such as people with disabilities, indigenous people, and ethnic minorities. They may even exacerbate existing imbalances, mainly if one considers that all previous industrial revolutions were characterized by an uneven distribution of benefits.

The above requires the adoption of a systemic approach and a continuously changing strategy which prioritizes four cross-cutting areas identified by UNIDO: **1) promoting knowledge creation, commercialization and skill-building; 2) ensuring the inclusion of vulnerable sections of the population; 3) building institutions (norms, standards and conventions); and 4) leveraging multi-stakeholder partnerships.**

As suggested in this report, it is essential to build a new set of skills in the workforce; to develop the required infrastructure, and to implement a combination of adaptation and mitigation strategies that enhance and address countries' strengths and weaknesses. However, it is important to ensure those set of actions are an integral part of a far-reaching strategy not only oriented to strengthen the national and regional capacities to adopt technologies but also to adapt, reinvent and produce new technologies. In the case of Mexico, this could progressively reduce its current dependence on imports of Advanced Digital Production (ADP) technologies and improve its position in the generation of related patents.

Building closer collaboration between industry, academia, and government lead not only to the creation of new knowledge, but it also facilitates its commercialization. Although this might seem a straightforward process, this report has shown that aligning industry requirements with the capabilities of research institutions and government priorities usually entails meaningful changes. Nevertheless, irrespectively of the strategy followed, the latter must be suitably informed by the country-specific conditions under which it will be implemented.

Moving towards the 4IR requires highly skilled and creative workers with substantial technological know-how. Nonetheless, in increasing their 4IR readiness, countries should carefully analyse and reform national educational systems and training programmes. While skills upgrading schemes are a crucial component in ensuring a smooth transition to the 4IR, the development of a highly competent workforce is insufficient to overcome the pitfalls of low competitiveness and productivity, particularly in the long run. A timely and targeted intervention to enhance creative disciplines and to foster innovation and ingenuity among and across economic sectors is more likely to have a sustainable economic and social impact.

In setting forward a truly inclusive approach in which all stakeholders have their interests represented, QI systems and the CE approaches play an essential role. On the one hand, the CE can strengthen the manufacturing industry, increase its competitiveness and at the same time address the growing inequalities between and within countries. Furthermore, 4IR technologies can accelerate the process of moving away from the dominant linear consumption and production system. On the other hand, the promotion of QI plays a key role in both supporting the integration of SMEs into global innovation schemes and GVCs and strengthening local capacities for facilitating technological appropriation.

The 4IR transformation will require a significant amount of resources, not only financial but also knowledge and human resources. This demands new forms of collaboration and partnerships to ensure that the combined effort of the different stakeholders has a positive contribution on the economy, the environment and society at large. The promotion of partnerships and global forums for knowledge dissemination and technology transfer is of utmost importance because it attracts investment, stimulates cooperation and facilitates networking. Events such as the ITM are key elements for narrowing the distance between stakeholders, for creating a platform in which ideas can be exchanged and where new areas of cooperation can be identified and grown.



The level of participation reported (exceeding 30,000 participants, among which 12,000 were students); the presence of high-level representatives from the federal and local governments, national and international industry and academic leaders; and the fact that the event went beyond business sales expectations (by more than 63%) bear witness to the positive impact of the ITM 2019 concerning efforts to ensure a smooth transformation to the 4IR in Mexico and the Latin America and the Caribbean region.

Industry 4.0 represents a great opportunity for companies as it gives access to a horizon of possibilities to increase the organization's benefits by optimizing the overall performance of the value chain, reducing risks, improving the time-to-market, gaining more flexibility, driving innovation. Mexico is developing in all industrial sectors with a broader focus on understanding the impact of initiatives towards industrial development. The CE principles grasped from household level will further the country's industrial development. The message conveyed during ITM 2019 urged business enterprises and academia to become innovative and collaborative for sustainable industrial development.

All stakeholders recognized that they have a crucial role towards adapting to Industry 4.0. Strengthening industry, academia and government collaborations is essential for industrial transformation both at regional and national levels. Decisions should be informed by country-specific conditions; thus, many models can be tailored to address challenges.

Mexico has already taken important steps in developing and implementing national programmes and strategies to accelerate industrial transformation (such as the road map for Industry 4.0 and PROSOFT). On the other hand, Mexico has set an important precedent with the establishment of regulatory frameworks for new technologies, such as the approval of the so-called Fintech law. Yet, efforts are still needed to define unified public policies and strategies to ensure their long-term continuity for enduring electoral cycles. Furthermore, despite the country concurrently having 98 research centers for advanced manufacturing and innovation and 34 industrial clusters focused on Industry 4.0 technologies, many of these initiatives tend to be industry-specific and hoarded by a reduced number of industries. This will require a greater investment effort to expand and improve the country's preparedness and capabilities to embrace the 4IR.

Key points

- If not adequately managed, the 4IR could contribute to preserve or even aggravate the existing inequalities, especially among vulnerable groups.
- In strengthening cooperation between industry, academia and government, there cannot be a one-size-fits-all model. Decisions should be informed by country-specific conditions.
- The implementation of strategies that prioritize systematic appropriation over adoption have a greater potential to mitigate the reliance on technology imports.
- A timely and targeted intervention to enhance creative disciplines and to foster innovation among and across economic sectors is more likely to have a sustained economic and social impact.
- If properly employed, 4IR technologies can facilitate a transition from the dominant linear consumption and production system.
- Events such as the ITM are key for narrowing the distance between stakeholders, for creating a space where new areas of cooperation can be identified and grown.

REFERENCES

- ¹ Rodriguez, J.P. (2020). *The Geography of Transport Systems*. 5th Edition, New York: Routledge. 456 pages. ISBN 978-0.
- ² The World Bank (2018). Trade (% of GDP) – Mexico. World Bank national accounts data, and OCDE national accounts data files. <https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?locations=MX>
- ³ World Trade Organization (2019) *World Trade Statistical Review*. https://www.wto.org/english/res_e/statis_e/wts2019_e/wts19_toc_e.htm
- ⁴ Trading Economics (2018). Mexico Exports by Category. <https://tradingeconomics.com/mexico/exports-by-category>
- ⁵ United Nations Industrial Development Organization (2019). *Competitive Industrial Performance Report 2018*. <https://www.unido.org/news/unido-publishes-new-competitive-industrial-performance-report>
- ⁶ Ynzunza Cortés, C. B.; Izar Landeta, J.M. ; Bocarando Chacón, J. G.; Aguilar Pereyra, F. ; and Larios Osorio, M. (2017). *El entorno de la industria 4.0: Implicaciones y perspectivas futuras*. Instituto Tecnológico de Aguascalientes. *Conciencia Tecnológica* No. 54.
- ⁷ Ministry of Economy (2016). *Crafting the Future. A roadmap for Industry 4.0 in Mexico*. <file:///G:/TII%20BCI/Mexico%20investment%20innovation%20programme/industry-4.0-mexico.pdf>
- ⁸ Secretaría de Hacienda y Crédito Público (2018). *El sector Fintech y su regulación en México*. <https://www.gob.mx/shcp/articulos/el-sector-fintech-y-su-regulacion-en-mexico>
- ⁹ *Gaceta económica* (2019) México, la segunda economía más competitiva de América Latina, FEM. <https://www.gob.mx/shcppercent7Cgacetaeconomica/documentos/mexico-la-segunda-economia-mas-competitiva-de-america-latina>
- ¹⁰ Plecher, H. (2020). Mexico: Distribution of the workforce across economic sectors from 2009 to 2019. <https://www.statista.com/statistics/275428/distribution-of-the-workforce-across-economic-sectors-in-mexico/>
- ¹¹ Pasquali, M. (2019). Value added to gross domestic product by the manufacturing sector in Mexico from 2010 to 2018. <https://www.statista.com/statistics/1075745/manufacturing-industry-added-value-gdp-mexico/>
- ¹² Calatayud A. and Katz R. (2019). *Cadena de suministro 4.0: Mejores Prácticas Internacionales y Hoja de Ruta para América Latina*. Banco Interamericano de Desarrollo (BID). https://publications.iadb.org/publications/spanish/document/Cadena_de_suministro_4.0_Mejores_practicas_internacionales_y_hoja_de_ruta_para_América_Latina_es.pdf
- ¹³ World Economic Forum (2016). *Digital Transformation of Industries Automotive Industry*. White Paper, in collaboration with Accenture. https://www.accenture.com/_acnmedia/accenture/conversion-assets/wef/pdf/accenture-automotive-industry.pdf
- ¹⁴ Tetra Pak (2018). *Industria 4.0 por Tetra Pak*. https://assets.tetrapak.com/static/mx/documents/industria_4.0_por_tetra_pak_espanol.pdf

- ¹⁵ PROMEXICO (2016). Electrodomésticos. Perfil del sector, mapa de clúster, información estatal y casos de éxito. <https://www.gob.mx/promexico/acciones-y-programas/electrodomesticos>
- ¹⁶ Clúster de electrodomésticos – CLELAC (2019). La industria de electrodomésticos en México. <http://www.clelac.org.mx/nacional.php>
- ¹⁷ United Nations Industrial Development Organization (2019) Industrial Development Report 2020. Industrializing in the digital age. Vienna. <https://www.unido.org/resources-publications-flagship-publications-industrial-development-report-series/idr2020>
- ¹⁸ Mexican Association of Machinery Distributors (2019). <https://amdm.org.mx/>
- ¹⁹ Secretaria de Economía (2018). El desarrollo de la Industria 4.0 en México. <https://www.gob.mx/se/articulos/el-desarrollo-de-la-industria-4-0-en-mexico?idiom=es;>
- ²⁰ Secretaria de Economía (2019). Conoce las Reglas de Operación del Programa para el Desarrollo de la Industria del Software (PROSOFT) y la Innovación 2019. <https://www.gob.mx/se/articulos/conoce-las-reglas-de-operacion-del-programa-para-el-desarrollo-de-la-industria-del-software-prosoft-y-la-innovacion-2019>
- ²¹ United Nations Industrial Development Organization (2018). Industry 4.0 – the opportunities behind the challenge. Vienna. https://www.unido.org/sites/default/files/files/2018-11/UNIDO_GC17_Industry40.pdf
- ²² Casalet M. (2018) La digitalización industrial: un camino hacia la gobernanza colaborativa. Estudios de casos. CEPAL and GIZ. https://repositorio.cepal.org/bitstream/handle/11362/44266/1/S1800941_es.pdf
- ²³ ITMastersMAG (2019). Inauguran centro avanzado de tecnología en manufactura en CDMX. <https://itmastersmag.com/noticias-analisis/inauguran-centro-avanzado-de-tecnologia-en-manufactura-en-cdmx/>
- ²⁴ Comisión Intersecretarial para el Desarrollo del Gobierno Electrónico (2019). 42ª sesión del Consejo Educativo de la CIDGE. <https://www.gob.mx/cidge/articulos/42a-sesion-del-consejo-ejecutivo-de-la-cidge?idiom=es>
- ²⁵ Secretaria de Economía (2019). Anuncia el gobierno de México nueva política industrial. <https://www.gob.mx/se/prensa/anuncia-el-gobierno-de-mexico-nueva-politica-industrial-221132>
- ²⁶ Secretaria de Economía (2016). Programa para la productividad y competitividad Industrial (PPCI) <https://www.gob.mx/se/acciones-y-programas/programa-para-la-productividad-y-competitividad-industrial-ppci>
- ²⁷ Forbes México (2018). Industria 4.0: Oportunidades y retos en México. <https://www.forbes.com.mx/industria-4-0-oportunidades-y-retos-en-mexico/>
- ²⁸ Noealt (2019). Samples, Images and Snapshots. <https://www.noealtcorporateservices.com/apps/photos/album?albumid=5235586>
- ²⁹ Global Manufacturing & Industrialisation Summit (2019) GMIS official website. <https://www.gmisummit.com/about-gmis/>
- ³⁰ United Nations Industrial Development Organization (2016) Inclusive and Sustainable Industrial Development in Latin America and Caribbean Region. https://www.unido.org/sites/default/files/2015-07/UNIDO_in_LAC_Region_0.pdf

- ³¹ Schwab K. (2017). *The Fourth Industrial Revolution*. Crown Publishing Group Affiliated of Random House, New York, ISBN: 978-1-5247-5886-8.
- ³² Gideon R. (2016) *The Fourth Industrial Revolution*. A Davos Reader, in Foreign Affairs. https://books.google.com.mx/books?id=pdx5CwAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
- ³³ Earley M. (2019). Mexico Industry News, “*Sixty percent growth in the Mexican automotive industry expected through 2020*” accessed at <https://www.tecma.com/sixty-percent-growth-in-the-mexican-automotive-industry-expected-through-2020/>
- ³⁴ Schwab K. and Davis N. (2018). *Shaping the future of the Fourth Industrial Revolution: A guide to building a better world* (2018) Crown Publishing Group- Business and Economics. https://books.google.com.mx/books?id=NQhSDwAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
- ³⁵ Manda MI and Dhaou SB. (2019). Responding to the challenges and opportunities in the 4th Industrial revolution in developing countries. ICEGOV2019, 3-5 April 2019, Melbourne, VIC, Australia
- ³⁶ World Economic Forum (2019). 6 ways the least developed countries can participate in the Fourth Industrial Revolution. <https://www.weforum.org/agenda/2019/08/6-ways-least-developed-countries-can-participate-in-the-4ir/>
- ³⁷ European Regional Development Fund (2018). Industry 4.0 – opportunities and challenges for SMEs in the North Sea Region. <https://northsearegion.eu/growin4/>, <https://northsearegion.eu/media/7320/growin-40-desk-study.pdf>
- ³⁸ Cotteleer M., Sniderman B. (2017). Forces of change: Industry 4.0. <https://www2.deloitte.com/us/en/insights/focus/industry-4-0/overview.html>
- ³⁹ Preston, F. and Lehne, J. A (2017). *Wider Circle? The Circular Economy in Developing Countries*, Chatham House, London.
- ⁴⁰ Hanf, M. (2019), What is circular economy and why is it relevant to you? <https://www.taival.com/stories/circular-economy-what-is-it>
- ⁴¹ Mark L. (2019). Circular economy, sustainability, manufacturing supply, energy policy on enabling the Circular Economy <https://www.navigantresearch.com/news-and-views/on-enabling-the-circular-economy>
- ⁴² Pagoropoulos, A., Pigosso, D. C. A., & McAlone, T. C. (2017). The emergent role of digital technologies in the Circular Economy: A review. *Procedia CIRP*, 64, 19 – 24. <https://doi.org/10.1016/j.procir.2017.02.047>
- ⁴³ United Nations Industrial Development Organization (2019). Circular economy, impact financing and Industry 4.0. <https://www.unido.org/our-focus-cross-cutting-services-circular-economy/circular-economy-impact-financing-and-industry-40>
- ⁴⁴ Eley Metrology (2019). The Place of Metrology in Industry 4.0, <https://eyley.com/2018/10/12/the-place-of-metrology-in-industry-40/>
- ⁴⁵ Bohun M. (2019). Accreditation 4.0: Adapting to a new revolution. <https://www.quality.org/knowledge/accreditation-40-adapting-new-revolution>

- ⁴⁶ United Nations Industrial Development Organization (2020). Fourth Industrial Revolution, Department of TII brochure. Work-in –progress.
- ⁴⁷ United Nations Industrial Development Organization (2019). Industrial Resource Efficiency Division and CIRCULAR ECONOMY, https://www.unido.org/sites/default/files/files/2020-02/IRE%20and%20Circular%20Economy_0.pdf
- ⁴⁸ United Nations Industrial Development Organization (2019). CIRCULAR ECONOMY and the Emerging Compliance Regimes Division, https://www.unido.org/sites/default/files/files/2020-02/ECR%20and%20Circular%20Economy_0.pdf
- ⁴⁹ United Nations Industrial Development Organization (2019). Bracing for the New Industrial Revolution Elements of a Strategic Response Discussion paper.
- ⁵⁰ Jain P. and Mondal T. (2017) HfS Research. https://www.accenture.com/t20170531t102458__w__/us-en/_acnmedia/pdf-52/accenture-industry-4-excerpt-for-accenture-report.pdf
- ⁵¹ Technopolis & Research ICT Africa & Tambourine Innovation Ventures (2019). *Potential of the fourth industrial revolution in Africa, STUDY REPORT unlocking the potential of the fourth industrial revolution in Africa.*
- ⁵² Castellano F. (2019) <https://www.toptal.com/finance/market-research-analysts/drone-market>
- ⁵³ Littlejohns P. (2019). *The Internet of Things and big data: The key trends that could shape the future of insurance*, <https://www.nsinsurance.com/news/internet-of-things-and-big-data/>
- ⁵⁴ simPRO Software, (2018). *IoT and its impact on trade services.* <https://www.ecdonline.com.au/content/field-service/article/iot-and-its-impact-on-trade-services-123880323>
- ⁵⁵ Gaget L. (2018). 3D printing for agriculture: Top 7 of the best projects. In Sculpteo. <https://www.sculpteo.com/blog/2018/07/04/3d-printing-for-agriculture-top-6-of-the-best-projects/>
- ⁵⁶ Rice M. (2019) accessed at: <https://builtin.com/hardware/3d-printing-applications-examples>
- ⁵⁷ AMFG Blog (2019) The Evolution Of 3D Printing Materials Market: Trends and Opportunities In 2019, <https://amfg.ai/2019/11/21/the-evolution-of-3d-printing-materials-market-trends-and-opportunities-in-2019/>
- ⁵⁸ Rural Industries Research & Development Corporation. (2016). *3D Printing*. Charles Sturt University, Locked Bag 588, Wagga Wagga NSW 2678
- ⁵⁹ Baldwin J. (2019). 3D Printing Trends: 2019 Recap and 2020 Predictions, <https://blog.grabcad.com/blog/2019/12/09/3d-printing-trends-2019-2020/>
- ⁶⁰ *Start-ups Insight blog (2019). 8 Blockchain Startups Disrupting The Agricultural Industry* ,<https://www.startup-insights.com/innovators-guide/8-blockchain-startups-disrupting-the-agricultural-industry/>
- ⁶¹ Marr B. (2019). 5 Blockchain Trends Everyone Should Know About'.<https://consensys.net/blockchain-use-cases/energy-and-sustainability/>
- ⁶² CBI Insights blog (2018). Trends Shaping The Future Of Blockchain Technology. <https://www.cbinsights.com/research/blockchain-future-trends/>

- ⁶³ Küpper D., Ströhle J., Krüger T., Burchardi K., and Shepherd N. (2019). Blockchain in the Factory of the Future, <https://www.bcg.com/publications/2019/blockchain-factory-future.aspx>
- ⁶⁴ Disruptive Asia blog (2019) “1+4” 5G application scenarios for open and convergent edge, <https://disruptive.asia/application-scenarios-for-open-convergent-edge/>
- ⁶⁵ Groopman J. (2017). 6 technology convergences to watch in 2018, <https://www.infoworld.com/article/3244247/6-technology-convergences-to-watch-in-2018.html>
- ⁶⁶ United Nations Industrial Development Organization (2019). Nature-like and Convergent Technologies Driving the Fourth Industrial Revolution, https://www.unido.org/sites/default/files/files/2020-01/Convergent_tech.pdf
- ⁶⁷ Roland C. (2018). The complete and modern guide to technology convergence, <https://shape.att.com/blog/technology-convergence>
- ⁶⁸ Thomas L. (2018). Sensors in Clean Technology. <https://www.azocleantech.com/article.aspx?ArticleID=817>
- ⁶⁹ Gall R. (2018) Energy sources and power management in IoT sensors and edge devices; <https://jaxenter.com/energy-sources-power-management-iot-sensors-edge-devices-145006.html>
- ⁷⁰ Sapovadia R. (2016). Harnessing the power of IoT for Energy Efficiency, Sensors & Data Harvesting <https://www.einfochips.com/blog/harnessing-the-power-of-iot-for-energy-efficiency-sensors-data-harvesting/>
- ⁷¹ Smith P. (2018). *The Role of Sensors in Industry 4.0*, <https://www.manufacturingtomorrow.com/article/2018/10/the-role-of-sensors-in-industry-40/12293>
- ⁷² Lozano J., Apetrei C., Ghasemi-Varnamkhist M., Matatagui M. and Santos J.P. (2017). Sensors and systems of environmental monitoring and control, https://www.researchgate.net/publication/320734657_Sensors_and_Systems_for_Environmental_Monitoring_and_Control
- ⁷³ Hubbell B.J., Kaufman A., Rivers L., Schulte K., Hagler G., Clougherty J., Cascio W., and Costa D. (2017). Understanding Social and Behavioral Drivers and Impacts of Air Quality Sensor Use, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6705391/>
- ⁷⁴ McGrath M.J., Ní Scanail C., (2014). Environmental Monitoring for Health and Wellness, accessed at: https://link.springer.com/chapter/10.1007/978-1-4302-6014-1_11
- ⁷⁵ I-scoop (2019). Industry 4.0: the fourth industrial revolution – guide to Industrie 4.0, accessed at: <https://www.i-scoop.eu/industry-4-0/>
- ⁷⁶ Soloman S. (2011). Industrial sensors and control–The basics–Part I, accessed at: <https://www.eetimes.com/industrial-sensors-and-control-the-basics-part-i/>
- ⁷⁷ Reportero Industrial Mexicano (2019) Informative magazine interview to UNIDO Representative and Regional Director Mr. G. Castella, at ITM 2019. <https://youtu.be/b-l8Vz8aVzc>



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