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The Opportunities and Challenges of Industry 4.0 for Industrial Development

A Case Study of Morocco's Automotive and Garment Sectors

Georgeta Vidican Auktor

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Abstract

The development and application of advanced manufacturing technologies (known as Industry 4.0) have been enabled by the fast-paced process of digital transformation. These transformations are expected to have major implications on the reorganisation of global value chains as well as on labour markets. For late-industrialising countries, Industry 4.0 brings both opportunities and challenges. On the one hand, it opens opportunities in terms of improving competitiveness, learning and export markets. On the other hand, however, it may devalue the traditional competitive advantage based on low labour costs, creating difficult-to-tackle challenges on labour markets related to unemployment and new demands for reskilling and upskilling. This paper explores these aspects through the lens of one country, Morocco, and two very different sectors: automotive and apparel. Morocco is a lower-middle-income country that has capitalised on its proximity to Europe and succeeded in developing a dynamic export-oriented automotive industry. The garment sector, which is critical for employment, has been generally neglected by the industrial development strategies. However, Industry 4.0 and its implications on global value chains are likely to affect both sectors, although in different ways. Our analysis clearly shows that interventions must be tailored to the different degrees of technological readiness. The automotive sector is driven more by the needs of major original equipment manufacturers. Therefore, industrial policy should focus on setting the framework conditions, enabling upgrading by investing in research and development, and shifting incentives towards facilitating local suppliers to better integrate with higher-tier suppliers. In the garment sector, policy interventions need to be more comprehensive, from developing a long-term vision to building awareness on technological upgrading and new business models enabled by digitalisation and automation. Moreover, there is extensive scope for industrial policy to contribute to building basic technological and knowledge capabilities all along the garment supply chain and to attracting investment.

Keywords: Industry 4.0, Morocco, automotive, garment

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February 2022 Georgeta Vidican Auktor

Contents

Figures

Tables

Boxes

Abbreviations

ADD	Agency for Digital Development /Agence du Developpement Digital (Morocco)
AMICA	Automotive Industry Association / Association Marocaine pour l'Industrie et la Construction Automobile (Morocco)
APEBI	Federation of Information Technology, Telecommunications and Offshoring Industry / Fédération des Technologies d'Information de Télécommunication et de l'Offshoring (Morocco)
AI	artificial intelligence
AMDIE	Moroccan Investment and Export Development Agency / l'Agence Marocaine de Developpement des Investissements et des Exportations
AMITH	Moroccan Association for the Textile and Garment Industry / Association Marocaine des Industries du Textile et de l'Habillement
CAD	computer-aided design
Casa Moda	Ecole Supérieure de Création et de Mode (Morocco)
CCoA	Competence Centre on Automation (Morocco)
CEE	Central and Eastern Europe
CETIEV	Technical Center of Vehicle Equipment Industries / Centre Technique des Industries des Equipements pour Vehicules (Morocco)
CNC	computer numerically controlled
CTTH	Technical Center for Textile and Clothing / Centre Technique du Textile et de l'Habillement
C2TM	Moroccan Cluster for Technical Textiles / Cluster des Textiles Techniques Marocains
ERP	enterprise resource planning
ESITH	Higher Education Institute for Textiles and Clothing / l'École Supérieure des Industries du Textile et de l'Habillement (Morocco)
EU	European Union
GVC	global value chain
ICT	information and communication technologies
IFMIA	Automotive Industry Training Institute / Institut de Formation des Metiers de l'Industrie Automobile (Morocco)
IoT	Internet of Things
ITC	International Trade Center (Geneva)
MarocPME	National Agency for the Promotion of Small and Medium-sized Enterprises / l'Agence Nationale pour la Promotion de la Petite et Moyenne Entreprise
MDFC	The Moroccan Denim and Fashion Cluster
MENA	Middle East and North Africa
MSMEs	micro, small and medium enterprises
NDM	New Development Model / le Nouveau Modéle de Développement (for Morocco)
OECD	Organisation for Economic Co-operation and Development
OEM	original equipment manufacturer
OFPPT	Office of Vocational Training and Employment Promotion / Office de la Formation Professionnelle et de la Promotion du Travail

PAI	Industrial Acceleration Plan / Plan d'Acceleration Industrielle (Morocco)
R&D	research and development
RFID	radio frequency identification
US	United States
VAT	value-added tax
3D	three dimensional

1 Introduction

The 21st century is defined not only by increased competition in highly integrated global markets, but also by fast-paced technological developments and the imperative to transition towards sustainable growth models. Digital transformation has enabled the development and use of advanced technologies in manufacturing, opening the way for the Fourth Industrial Revolution, known as Industry 4.0. Its implications for the production of goods and services and on global value chains (GVCs) are expected to be wide-ranging, resulting in long-term productivity and efficiency improvements driven by reduced labour costs (due to higher levels of automation), improved product offers (due to flexibility in product design and development), and more efficient (i.e. less wasteful) asset utilisation (due to greater optimisation) (Drahokoupil, 2020; Lütkenhorst, 2018; Organisation for Economic Co-operation and Development [OECD], 2017a).

Automation in production is, of course, not new, but since the 1970s it has accelerated due to the fast dissemination of electronics, information and communication technologies (ICT) as well as human-assisted robots (a period known as the Third Industrial Revolution, or Industry 3.0) (Schwab, 2016). The current era, however, is one of more rapid, fundamental and systemic changes affecting the production process, where technologies such as cyber-physical systems, the Internet of Things (IoT), cloud computing, artificial intelligence (AI), additive manufacturing (also known as 3D printing) and advanced robotics become much more embedded in the manufacturing process across sectors. These technologies have become central to industrial development strategies in (labour-scarce) developed economies in the last decade and have been widely adopted in sectors ranging from food production to automotive and aeronautics.

For late-industrialising countries, the digital transformation is a double-edged sword. On the one hand, it opens many opportunities for improving competitiveness, learning and entering GVCs. On the other hand, however, entry barriers are high in terms of know-how (i.e. advanced skills), capital investment and economies of scale. In addition, such technological transformations tend to devalue the traditional competitive advantage stemming from low labour costs. Moreover, the current state of technological capabilities, absorption capacity and technology endowment remain deficient in most late-industrialising countries, excluding a large number of countries and (especially micro, small and medium enterprises, MSMEs) firms from harnessing the benefits. This suggests that even where investments in more advanced manufacturing processes are undertaken, opportunities for spillover effects, upgrading and the integration of MSMEs into global trade are likely to remain minimal.

This is particularly important as digital transformation creates not only benefits in terms of higher levels of productivity and efficiency. Digital technologies may also lead to "decentralisation of advanced activities across the production network, allowing production sites to be upgraded through advanced manufacturing technologies" (Drahokoupil, 2020, p. 7). Therefore, a delay in adopting such technologies may raise the risk of developing countries falling behind in terms of competitiveness. This may be reinforced by the resulting possibility of reshoring (backshoring) production to high-income countries and a shortening of GVCs, facilitated by automation and digitalisation (Altenburg, Chen, Lütkenhorst, Staritz, & Whitfield, 2020; Drahokoupil, 2020; Hallward-Driemeier & Nayyar, 2018; Lütkenhorst, 2018). Moreover, as Industry 4.0 is expected to have significant impacts on

labour markets (given the labour-saving character of digital technologies and changes in the required skill mix of workers), social inequalities and poverty levels may be heightened especially in low-income countries that rely on the production and export of labour-intensive goods. These trends, therefore, may contribute to an acceleration of premature deindustrialisation[1] (Altenburg et al., 2020; Rodrik, 2016, thereby bringing into question the viability of a manufacture-led growth model for developing countries.

To reduce the likelihood of and the risks associated with this ominous scenario and to align national visions and development strategies with the realities of the 21st century, developing countries have to better position themselves to harness opportunities created by digital transformation. For instance, 3D printing could "democratise production" (Hallward-Driemeier & Nayyar, 2018) by facilitating manufacturing in multiple locations closer to the customers. Advanced manufacturing technologies could also accelerate the upgrading of firms in production networks. The current trend towards the servicification of manufacturing could increase employment opportunities. Digitalisation could open export opportunities for MSMEs by reducing the cost of matching buyers and sellers. Lastly, the change in required skills could trigger major improvements in education and training at all levels and reduce the prevailing mismatch of skills.

Motivated by these challenges faced by low- and middle-income countries in their latecomer industrialisation endeavours and by the potential opportunities that could be harnessed by actively engaging in the digital transformation, this discussion paper investigates several research questions (two more general and three more specific questions).

This paper examines the **following general questions**:

1. How is digital transformation likely to impact supply chains in low- and middle-income countries?

2. What are the implications on employment, location of production and global production networks?

As digital technologies are very differently integrated in the production process of various sectors, and since the pattern of specialisation varies across countries, this paper also explores the concrete opportunities and challenges of Industry 4.0 in two sectors: *the automotive sector*, a technology-intensive sector defined by extensive global production networks (i.e. the automotive); and *the garment/apparel sector*, a traditional export-oriented, labour-intensive sector that represents an important source of employment and revenue for many developing countries.

Drawing on extant literature, secondary data and qualitative interviews with relevant stakeholders, we explore these sectors more generally as well as in the context of Morocco, a lower-middle-income country that has capitalised on its proximity to Europe and succeeded in developing a dynamic export-oriented automotive industry. The garment

1 Premature deindustrialisation refers to the process by which many developing countries are "becoming service economies without having had a proper experience of industrialisation" (Rodrik, 2016). Under pressure of globalisation and international trade, the manufacturing sector in these countries loses both in terms of employment and output shares, significantly undermining growth potentials.

sector has also been critical for Morocco's industrialisation strategy and an important source of employment and foreign exchange. Furthermore, Morocco has embarked on an ambitious path to advance digitalisation in the economy and the public sector. Examining how digital transformation is likely to affect Morocco's future industrialisation prospects can, therefore, offer important lessons for other low- and middle-income countries seeking to follow a similar path. In addition, insights from this paper could also guide the international development institutions supporting them in their upgrading process.

In this context, **the following more specific questions** will be examined:

3. How does Industry 4.0 manifest in the automotive and garment sectors? Specifically, what are the implications on employment, upgrading and location of production?

4. How prepared are these sectors in Morocco to engage with digital technologies, given the level of technological capabilities and prospects for development?

5. How can industrial policy-makers respond to the trends in digital transformation in production to address the development goals of Morocco?

We find that Morocco's strategic industrial development strategy of the last decade has created unprecedented opportunities for it to take advantage of emerging global and regional transformations generated by the proliferation of advanced manufacturing technologies. These opportunities are, however, not uniformly present across the manufacturing sector, nor do they offer a guarantee for success. The automotive sector has grown to become regionally competitive and increasingly integrated along the supply chain, having attracted important original equipment manufacturers (OEMs) and countless international suppliers. The sector has also gradually shifted from assembly-only to the local manufacturing of key parts and components and more sophisticated engineering services. This solid base of technological capabilities may further incentivise parent companies to increasingly shift research and development (R&D) activities from (labour- and skill-scarce) core regions of Europe to Morocco, since digital transformation increases the complexity and software-intensity of all value-adding processes (Szalavetz, 2020).

The labour-intensive garment sector in Morocco finds itself at an oppositive spectrum of performance. Long neglected in national development strategies and having suffered from price-based competition from Asian competitors, digital transformation and technological upgrading has barely touched the majority of small and medium-sized firms dominating the sector. Exceptions are a few large exporters whose upgrading strategies have been mostly customer-driven. Yet, we find major opportunities emerging primarily due to pressure for the nearshoring of garment manufacturing to reduce time-to-market and serve markets for customer-driven products. The scope for industrial policy in this sector is enormous, also in light of current efforts to integrate digital technologies in the private sector. National policy-makers, with the support of international development cooperation agencies, could contribute through targeted interventions to upgrade capabilities, upskilling and reskilling programmes, transfer of know-how and investment mobilisation. Especially in this labour-intensive sector, any delays in (or lack of) digital upgrading could be associated with a rapid loss of competitiveness with dire social consequences for those employed in the sector.

The paper is structured as follows:

- **Section 2** proceeds to summarise the existing literature on Industry 4.0 and its impact on the structure of supply chains, employment and technological capabilities (research questions 1 and 2).
- **Sections 3 and 4** examine these issues for the specific case of the automotive and garment sectors (research question 3).
- **Section 5** analyses the empirical evidence on the implications of digital transformation in Morocco in the two sectors (research question 4).
- **Section 6** concludes with guidelines for industrial policy-makers in Morocco and for development cooperation actors, and with reflections on implications for manufacturing-led development in other developing countries (research question 5).

2 Digital transformation in production and impacts on manufacturing

Before delving deeper into discussions on how Industry 4.0 impacts production at the sectoral level, this section briefly reviews: (a) the technologies generally considered to be part of Industry 4.0, their prevalence in manufacturing and their relevance; and (b) the various ways in which these technologies are expected to affect the production of goods and services more generally, with a focus on low- and middle-income countries. As these aspects have been extensively discussed in the literature, especially in the last five years, this section only summarises and critically reflects on these technological trends and their implications.

2.1 Technologies impacting production

Advanced manufacturing technologies generally associated with Industry 4.0 are commonly grouped into four interdependent categories reflecting their application in the production process (Culot, Nassimbeni, Orzes, & Sartor, 2020; Lütkenhorst, 2018; OECD, 2017a; among others):

- *Physical–digital interface technologies* (e.g. IoT) comprising advanced wireless technologies and sensors allowing the connection of people with machines and the subsequent collection of data and real-time decisions; visualisation technologies linking cyberspace with products, machines and workers.
- *Network technologies* (e.g. blockchain technology, interoperability and cybersecurity solutions, and cloud computing) providing online capabilities.
- *Data-processing technologies* (i.e. big data analytics, machine learning and AI, simulation, and modelling) aimed at supporting the analysis of live data from production systems.

- *Physical–digital process technologies* (e.g. advanced robotics in production and logistics, new materials, energy management solutions, human–machine interactions and 3D printing) that comprise equipment used in production.

The first three categories are often referred to as digital enablers, building on the advancement of ICT technologies that defined the Third Industrial Revolution. Physical–digital production systems "combine" these technologies with advanced process technologies.

The uniqueness of these (inter-connected) technologies rests on the novel way in which hardware, software and connectivity are "reconfigured and integrated" to achieve higher levels of productivity and efficiency (United Nations Industrial Development Organization [UNIDO], 2020) across sectors such as manufacturing, transport, energy, agriculture, retail and government.

The *hardware* type of technologies is largely similar to technologies introduced during the Third Industrial Revolution in sectors such as high-tech electronics, automotive and aeronautics. What sets them apart during the Industry 4.0 era, is the high level of connectivity and flexibility, which facilitates a much deeper integration of these technologies in the design, production, monitoring and control processes as well as interactions with customers.

Equipping hardware with sensors and actuators allows for a high level of *connectivity* between machines and people across locations. Sensors and actuators allow machinery to engage more actively with the environment by detecting changes in the production process and in the material and functional properties of products (enabling predictive maintenance, enhancing quality, optimising inventory as well as reducing energy and materials costs). Collecting large amounts of data and transmitting it across the production system is facilitated by the integration of these technologies, known as IoT.

To process the sizeable amount of data generated by connectivity, *software* enabling near-real-time big data analytics is crucial. Building upon technologies such as computer-aided manufacturing (CAM) and computer-aided design (CAD), the software supporting the advanced manufacturing technologies enabled so-called cyber-physical systems that support smart-networked systems of production and machine learning. As mentioned earlier, what sets Industry 4.0 technologies apart from previous technological innovations in production is their high level of interdependence and reliance on network connectivity across the supply chain.

Advanced digital production technologies ultimately enable the combination of physical and virtual dimensions of production, seamless interactions between smart machines, and the collection and analysis of vast amounts of data. The increased sophistication of these technologies, their application across sectors, the high level of interconnectivity on the factory floor and across supply chains, as well as the wide-ranging effects that can already be seen in early adopting (mostly high-technology) sectors are likely to significantly change not only production processes (transformations often subsumed in the concept of a "smart factory") more generally; such transformations may also question the accessibility and nature of future manufacturing-led development processes in low- and middle-income countries. Let us discuss below why this may be the case and where opportunities may be harnessed.

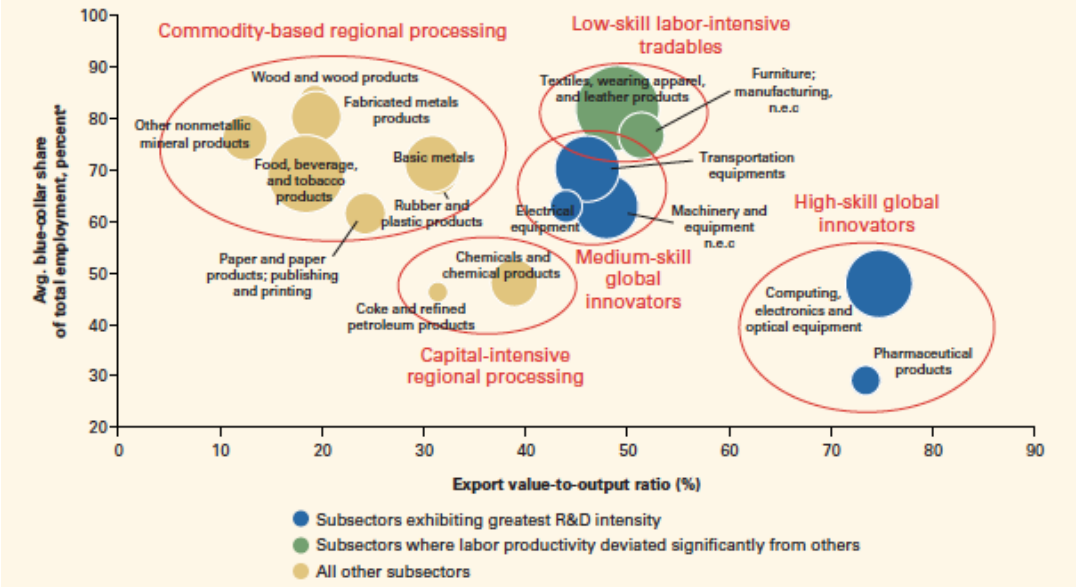
2.2 Expected impacts on manufacturing-led growth

The extent to which the continuous advancement of Industry 4.0 will weaken the industrialisation prospects of developing countries or enable them to leapfrog into using new technologies highly depends on their existing technological capabilities, degree of participation in GVCs and the complexity of firm ecosystems (Hallward-Driemeier & Nayyar, 2018; World Trade Organization [WTO], 2018; among others). Advanced manufacturing technologies may shorten GVCs, put employment (especially of unskilled labour) at risk and accelerate structural change towards the service sector. These impacts are going to, of course, differ across countries. More importantly, however, the impacts will also differ across manufacturing sub-sectors. For this reason, it is important to examine the manufacturing sector at the more granular level.

We do this by relying on Hallward-Driemeier and Nayyar's (2018) complex analysis. Figure 1a maps sectors across five main dimensions: (1) the trade intensity measured by export value-to-output ratio (the horizontal axis), (2) the share of unskilled (blue-collar) workers in total employment by sector (the vertical axis), (3) the share of manufacturing employment (the size of the bubbles), (4) the R&D intensity of the sector and (5) labour productivity. Bubbles coloured blue indicate the sub-sectors with the highest R&D intensity, while those coloured green indicate sub-sectors that deviated significantly from others in terms of labour productivity. Figure 1b shows the average share of blue-collar workers and robots per 1,000 workers by manufacturing sub-sector in 2011 in selected countries.

As Figures 1a and 1b show, automation and trade intensity are highest among sectors grouped as medium and high-skills innovators (e.g. transport equipment, electrical equipment, machinery and equipment, computing, electronics and optical equipment). Concerns with regard to the developmental impacts of the Fourth Industrial Revolution are, therefore, highest in these sectors, especially for countries where these sectors are not well integrated in GVCs. Even in low-skill labour-intensive tradables such as the textile and garment sectors, currently characterised by low levels of automation (measured by the use of robots in the production process), there is a potential risk of automation in the future, given the high share of blue-collar workers performing repetitive tasks.

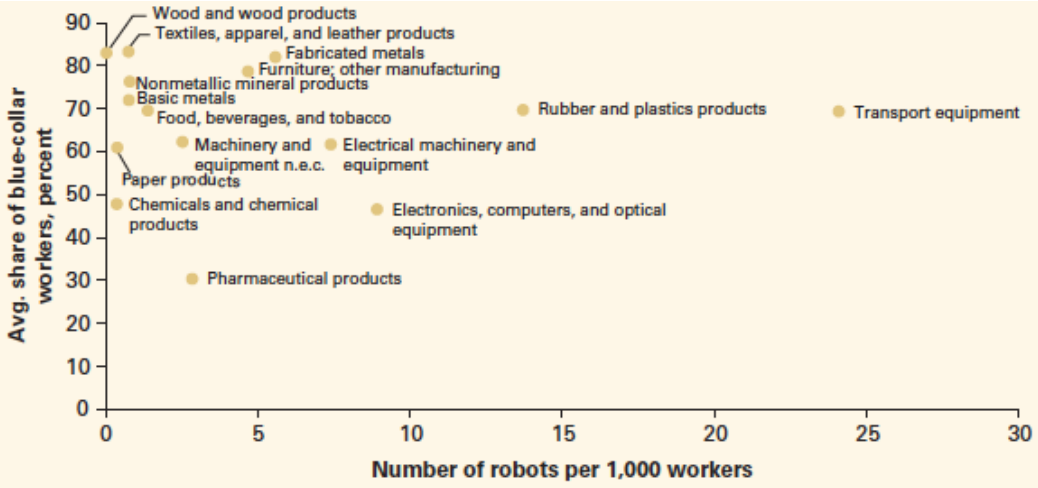
Figure 1a: Manufacturing sub-sectors, grouped by pro-development characteristics, 2013



Sources: Calculations based on United Nations Industrial Development Organization (UNIDO) Industrial Statistics (INDSTAT) database; UN Comtrade database; University of Minnesota's Integrated Public Use Microdata Series (IPUMS) International database.
Note: Bubbles colored blue indicate the five subsectors exhibiting the greatest R&D intensity. Bubbles colored green indicate subsectors that deviated significantly from others in terms of labor productivity. Bubble size indicates each manufacturing subsector's share of total manufacturing employment. n.e.c. = not elsewhere classified.
a. For blue-collar shares, occupations classified as International Standard Classification of Occupations (ISCO) groups 5, 7, 8, and 9 are labeled as blue-collar occupations. Total number of sector employees includes occupations classified as ISCO groups 1, 2, 3, 4, 5, 7, 8, and 9. Blue-collar shares are calculated at sector-by-country level for selected countries using census data harmonized by IPUMS International.

Source: Hallward-Driemeier and Nayyar (2018, p. 20)

Figure 1b: Average share of blue-collar workers and robots per 1,000 workers, by manufacturing sub-sector, selected countries, 2011



Sources: Calculations based on International Federation of Robotics (IFR) World Robotics database; and University of Minnesota's Integrated Public Use Microdata Series (IPUMS) International database; and United Nations Industrial Development Organization (UNIDO) Industrial Statistics (INDSTAT) database.
Note: Average blue-collar shares per subsector are calculated as follows: (1) Country sector blue-collar share is calculated using census data harmonized by IPUMS International. (2) Take simple average of blue-collar shares across 19 countries for which data are available. The sector aggregation is based on International Standard Industrial Classification (ISIC) rev. 3 two-digit classification. n.e.c. = not elsewhere classified.

Source: Hallward-Driemeier and Nayyar (2018, p. 139)

The expected impacts of these technological trends are varied and depend on the structure of the manufacturing sector as well as domestic technological and know-how capabilities. Four main hypotheses are commonly discussed in the literature in light of the advancement of Industry 4.0 globally. First, increased automation and digitalisation is likely to lead to the reorganisation of GVCs. Second, the demand for highly skilled workers will increase, and employment may dramatically decrease in some sectors. Third, an acceleration in the structural transformation of economies towards the service sector is to be expected. Lastly, Industry 4.0 can significantly contribute to a diversification of export markets, creating opportunities for traditional labour-intensive sectors (such as garment and food processing) to explore new business models. Let us review below the expected impacts from the diffusion and use of advanced manufacturing technologies on the location of production, employment and skills, the servicification of manufacturing (i.e. increasing role of the service sector in manufacturing) and the diversification of export markets.

2.2.1 Location of production

Given the impact of Industry 4.0 technologies on production costs, flexibility and efficiency in production, an important outcome of their wide dissemination is to change the pattern of globalisation by reshaping and further transforming GVCs. These effects are expected to be more intense for high-tech sectors for which GVCs' linkages are more significant and more complex involving many countries (Dollar, 2019).

In general, given the need for pre-existing technological capabilities, skills and industrial experience, low labour costs may not be enough anymore to attract investment in manufacturing. As a result, advanced technologies such as AI, 3D printing and robotics enabled by cyber-security systems may contribute to shortening GVCs through reshoring (backshoring or nearshoring) production, concentrating supply chains closer to major markets in Europe, North America and Asia.[2]

Interestingly, applying digital technologies allows low-cost manufacturing concentrations, such as China, to retain low-value-added manufacturing segments, shrinking opportunities for developing countries to expand into or to enter GVCs (Hallward-Driemeier & Nayyar, 2018). More specifically, in its rapid industrialisation process, China is likely to "replace jobs with robots", preventing therefore a further move of labour-intensive industries to low-wage developing countries (Altenburg et al., 2020; Andreoni & Anzolin, 2019, p. 3). As Andreoni and Anzolin (2019) explain, an important outcome of the Third Industrial Revolution was the "flying geese" phenomenon, by which rapidly industrialising countries move from labour-intensive to more capital-intensive industries, and thus relocate labour-intensive jobs to other developing countries. The key takeaway in the context of the Fourth Industrial Revolution is that this relocation of lower-skilled manufacturing processes may not happen anymore. Therefore, advanced technologies such as AI and data analytics are likely going to have a much larger impact on high- and low-value services, especially in labour-rich countries (Andreoni & Anzolin, 2019).

2 Yet, it is worth mentioning that evidence shows that backshoring is driven by quality and flexibility issues much more than labour costs, lack of qualified personnel or lack of infrastructure (de Backer, Menon, Desnoyers-James, & Moussiegt, 2016).

Although the overall potential of advanced manufacturing technologies, such as 3D printing, to disrupt trade is substantial (Arvis, Kent, Shepherd, & Nair, 2017), evidence of such trends in terms of the restructuring of GVCs remains limited by now (Drahokoupil, 2020; Hallward-Driemeier & Nayyar, 2018; among others). Yet, as also reinforced by the recent Covid-19 crisis, the increasing complexity and length of GVCs has exposed companies to high level of supply risks and reduced their agility to respond to changing consumer preferences (de Backer et al., 2016; Drahokoupil, 2020; Textile 4.0, 2020). Therefore, although backshoring may be less likely in sectors that are less technologically advanced, sectors that see high levels of investment in Industry 4.0 technologies and are characterised by complex GVCs, such as automotive, may see backshoring happening faster (Dachs, Kinkel, & Jäger, 2017). In addition, a shortening of supply chains is expected, especially in mid-technology sectors.

Freund, Mulabdic and Ruta (2019), for instance, suggest that while 3D printing allows for product customisation, traditional manufacturing is still a better option for the bulk production of simple items (and even for more specialised products). Disruption in comparative advantage is, however, observed for a large number of 3D printable goods and for bulky products with higher transport costs, with the benefits being captured by (capital abundant) developed and emerging economies to the detriment of (labour abundant) developing countries (Freund, Mulabdic, & Ruta, 2019). But evidence remains inconclusive, given limited data and early trends. More research is necessary to understand the effects on low- and middle-income countries as more data on the adoption of this technology in different sectors becomes available.

Another important trend that may open opportunities for "peripheral" production locations to upgrade and increase their participation in GVCs is the effect that Industry 4.0 technologies may have on the decentralisation of advanced activities across the regional networks of production (Drahokoupil, 2020). This would suggest less clear boundaries between the centre and periphery in terms of high value-added versus low value-added production patterns. This is especially relevant for sectors such as the automotive sector, defined by a complex global network of suppliers. Decentralisation of advanced activities such as engineering, design and software development may contribute to reducing the level of concentration in core headquarter locations, increasing efficiency (for instance, by reducing coordination and matching costs between buyers and suppliers, WTO (2018)) and flexibility in serving regional markets, as well as enabling "peripheral" producers/suppliers to accumulate technological and R&D capabilities (Szalavetz, 2020). This is especially important, given that advanced manufacturing technologies increasingly depend on co-locating R&D, innovation and production (de Backer et al., 2016).

2.2.2 Employment and skills

One of the most controversial impacts of productivity-enhancing advanced manufacturing technologies, especially for labour-rich low- and middle-income countries, is on labour markets and required skills. Three defining characteristics of these technologies raise concerns when it comes to employment. First, fast rates of technology innovation can make production technologies currently in use obsolete (Komlos, 2016). Second, technologies such as 3D printing and advanced robotics may promote jobless growth or "jobless recovery" (Brynjolfsson & McAfee, 2012). In particular, the widely cited study of Frey and Osbourne (2013) claims that about 47 per cent of persons employed in the United States

(US) and an average of 57 per cent across the countries of the Organisation for Economic Co-operation and Development (OECD) (Frey & Osbourne, 2015) work in jobs that are at risk of being automated in the next 10-20 years. Interestingly, as Acemoglu and Autor (2011) show, it is the medium-skilled jobs that are more likely to be automated than the highly skilled or unskilled jobs.[3] This is primarily because middle-skilled cognitive and manual jobs are characterised by routine tasks (such as bookkeeping, clerical work, repetitive production and monitoring jobs).[4]

Third, software and connectivity systems facilitate the creation of new business models that can reach customers and suppliers not only with less physical capital but also with lower numbers of workers (Soete, 2018).

Aside from an impact on the number of jobs, Industry 4.0 technologies are also expected to affect the nature of required skills, increasing demand for highly skilled professionals (Drahokoupil, 2020; WTO, 2018), which may lead to skill premia (Ahmed & Chen, 2017).[5] Effective reskilling and retraining policies are challenging, as they require both a long-term development strategy aligned with these technology trends and close cooperation and coordination between the private sector, trade unions and policy-makers to be able to understand industry-specific trends and requirements.

However, empirical evidence shows that the pessimistic scenarios predicting dramatic job losses due to automation have not (yet) materialised, primarily for three main reasons. First, the diffusion rate of related technologies still remains low, especially among the MSMEs that make up more than 90 per cent of firms even in high-income countries (Autor, Mindell, & Reynolds, 2020; Drahokoupil, 2020). In low- and middle-income countries, constraints on absorptive capacity, available skills and ability to mobilise large capital investments have made it difficult to substitute labour, especially in the MSME sector (Hallward-Driemeier & Nayyar, 2018). Moreover, as Falco, Maloney, Rijkers and Sarrias (2015) show, the share of medium-skilled jobs that may be more susceptible to automation is expected to be relatively small.

Second, the creative-destructive nature of technological innovation ensures that, even if jobs are being lost in the process of digital transformation in production, new jobs are being created in the economy. As the jobs most susceptible to automation are middle-skilled jobs (Acemoglu & Autor, 2011) and since the newly created jobs are skewed towards high-skilled/high-income occupations and non-routine, low-skilled jobs – creating even higher levels of labour market polarisation[6] – these new jobs become traditionally high-wage and

3 The discussion and evidence on the relationship between automation and skills gets more nuanced when we differentiate between jobs, skills and occupations. While an extensive review of the literature on this topic is beyond the scope of this paper, more insights could be gained from, among others, Frey and Osbourne (2015) and Arntz, Gregory and Zierahn (2017).

4 "Because the core job tasks of these occupations follow precise, well-understood procedures, they can be (and increasingly are) codified in computer software and performed by machines (or, alternatively, are sent electronically – 'outsourced' – to foreign workers" (Acemoglu & Autor, 2011, p. 1076).

5 Skill premia, referring to the wage differential between a skilled and unskilled worker, will rise if the pace of skill-biased technological change exceeds the pace of skilled labour supply growth.

6 Labour market polarisation is not only the result of digitalisation. International trade also contributed to this outcome since the intensification of globalisation (Autor & Hanson, 2016).

traditionally low-wage occupations (Autor et al., 2020; Hallward-Driemeier & Nayyar, 2018; Peralta-Alva & Roitman, 2018). Acemoglu and Autor (2011) describe these peripheral jobs as those that are characterised by abstract tasks (on the high end of skills) and by manual tasks (at the low end of tasks). Abstract tasks require problem-solving, intuition, persuasion and creativity. These tasks are characteristic of professional, managerial, technical and creative occupations such as science, engineering, design, management, law and medicine (Acemoglu & Autor, 2011). Non-routine manual tasks require in-person interactions, situational adaptability as well as visual and language recognition, which may require little in the way of formal education (Acemoglu & Autor, 2011).

While such trends are not yet widely seen in low- and middle-income countries, early signs have been found in some emerging economies such as Brazil, Indonesia and Mexico (Maloney & Molina, 2016). This outcome reinforces the importance of reskilling and retooling programmes and social protection measures to cushion the negative effects of those affected by technological unemployment. The relevance of these trends emerges also from the prevailing view that the jobs which are going to be created will be insufficient, especially those with the highest risk of being automated (Andreoni & Anzolin, 2019; Frey, 2017).

A third aspect, however, relates to a lack of consensus on the job loss effects, especially due to whether what is being measured are occupations or tasks performed. Specifically, the large job loss estimates of Frey and Osbourne (2013, 2015) focus on occupations in which the risk of automation is high. Yet, as various other studies show (Ahmed & Chen, 2017; Arntz et al., 2016; Autor et al., 2022), given that an occupation comprises several tasks and that not all tasks will be automated, a task-based approach leads to significantly lower job loss estimations. For instance, in contrast to the 47 per cent job loss estimates for the US and 57 per cent for the OECD countries, PricewaterhouseCoopers (2018) provides a 38 per cent job loss estimate for the US, while Arntz et al. (2016) find 9 per cent of jobs at risk of automation in OECD countries. For low- and middle-income countries, the threat of job automation is found to be even lower, at 2-8 per cent (Ahmed & Chen, 2017). This wide variation in job loss predictions therefore calls for caution in interpretations, depending on what is actually being measured. It also illustrates that more research is needed to fully understand the impacts of Industry 4.0 on labour markets (Lütkenhorst, 2018).

2.2.3 The servicification of manufacturing

Servicification refers to the process by which manufacturing firms not only buy and produce more services than before but also sell and export more production-related services as integrated activities (National Board of Trade of Sweden, 2016, in Hallward-Dreimeier & Nayyar, 2018). The accelerated diffusion of ICT technologies and digitalisation through IoT, which facilitates the generation, transmission and analysis of vast amounts of data (of growing relevance for “smart” factories), has already increased the relevance of services in the manufacturing process (Hallward-Driemeier & Nayyar, 2018).

This shift towards services happens along with the general trend that low- and middle-income countries are experiencing with regards to a decrease in the share of the manufacturing sector in their economies, an outcome that Palma (2014) and Rodrik (2016) have called premature deindustrialisation, as explained earlier.

Such services are gradually becoming more important for developing a competitive manufacturing sector, as data processing and data analytics play a growing role in optimising production processes.[7] Also, services embedded in manufacturing either as inputs (such as R&D, design, marketing or distribution) or as enablers for trade (related to sales and after sales services bundled with goods, such as logistics services or e-commerce platforms) (i.e. embodied services) represent a higher share in value added (Hallward-Driemeier & Nayyar, 2018). Therefore, the ICT services (associated with these embedded and embodied services) play an increasing role in boosting manufacturing competitiveness through IoT.

One widely discussed impact of servicification in manufacturing is that automation of previously offshored manufacturing as well as technologies such as 3D printing reduce the need to transport goods across borders for some products and instead emphasise trade in services (specifically in data flows, such as digital product design files) as part of the manufacturing process (Arvis et al., 2017; Freund et al., 2019). Therefore, as discussed earlier, for some products (or sectors), the pattern of trade may change as a result of shortened supply chains. For countries that already have a strong manufacturing sector, however, the servicification of manufacturing may create new export opportunities, new jobs and new sources of dynamic comparative advantage. One example, as we discuss later, is the emergence of export opportunities for advanced engineering services linked to the automotive sector in Morocco. The well-documented example of India's software industry also provides a clear illustration of such opportunities.

Yet, while the service sector provides opportunities for productivity growth also in the low- and middle-income countries (McMillan, Rodrik, & Sepulveda, 2017), they may not perform as well when it comes to job creation for unskilled labour (Nayyar, Cruz, & Zhu, 2018). This is especially because ICT-related services tend to be also characterised by medium- to high-skill intensity (Cruz & Nayyar, 2017). Therefore, Hallward-Driemeier and Nayyar (2018, p. 151) argue that "without sufficient human capital, there are limits to how much labour can be absorbed in highly skill-intensive service sectors".

Advanced manufacturing technologies are therefore accelerating structural change, thereby creating the need for developing countries to also gradually prepare to increase the availability and reliability of embodied and embedded services (and for skills in these sectors) in order to remain competitive in the medium and long term.

2.2.4 Diversification of export markets

Advanced manufacturing technologies may not be available or accessible for MSMEs in developing countries. But enabling technologies such as digital technologies that leverage the Internet to collect, store and process data – for example AI, IoT and blockchain – open new opportunities for MSMEs, both in terms of market access as well as in terms of participating in GVCs and international trade (WTO, 2018). Even at a more basic level, empirical evidence shows that wider diffusion and use of (already mature) digital technologies open a range of opportunities for MSMEs to play a more active role in GVCs

7 As Palma (2014, p. 20) argues, in the context of developing countries, this becomes a process of "uncreative destruction". Such outcomes may be further accelerated by the advancement of Industry 4.0 across the developing countries.

(Lanz, Lundquist, Mansio, Maurer, & Teh, 2018).[8] Such technologies not only reduce fixed trade costs for firms[9] (Cusolito, Safadi, & Tagioni, 2016), but also make new business models available for reaching customers and product markets (through online marketing and sales, online and mobile banking and finance, blockchain[10] and networking platforms for MSMEs) (see Table 1).

Table 1: Ways in which the digital economy can reduce MSME business costs

Export value chain	**Impact of Industry 4.0 technologies**	
	Traditional scenario	**Digital scenario**
Market research	Labour-intensive: dedicated staff, market research agency, field trip Potential travel to market	Desktop research Digital marketing research tools Reduced need for travel
Marketing	Procurement of advertising space in foreign market	Digital advertising channels (search engine optimisation, displays, social, video) Leveraging market platforms
Insurance and finance	Limited transparency Time-intensive paper-based approach Dedicated brokers	Product comparison sites Single window view into market Digital financial products
Regulatory compliance	Time-intensive paper-based approach Dedicated consultant	National single window
Distribution	Manual management of supply chains Limited information on causes of inefficiencies	Automated and digitised supply chain management (e.g. IoT)
Operational support	Special IT equipment (e.g. servers, office software) Communication services Dedicated travel agents	Cloud computing and software Voice over IP Online travel services

Source: Author, based on Ganne and Lundquist (2019)

Yet, among the key challenges that MSMEs face in engaging in GVCs are high levels of informality, especially in developing countries; resource disadvantage relative to large firms; inability to meet product and quality standards; insufficient knowledge on trade regulations; and poor physical and ICT infrastructure (Ganne & Lundquist, 2019). In addition, the digital economy has also made it increasingly difficult for MSMEs to become more competitive (and even enter international markets) due to higher degrees of complexity, changes in required skills and business models, and a "winner-takes-it-all"

8 Specifically, Lanz et al. (2018) find that MSMEs with a website tend to import a higher share of their inputs used for production and export a higher share of their sales as compared to MSMEs without a website. Moreover, MSMEs tend to participate more in GVCs in countries where a higher share of the population has fixed broadband subscriptions.

9 The Asia Pacific MSME Trade Coalition (2018) estimates that digital technologies can reduce MSMEs' export costs by as much as 82 per cent and reduce foreign market operation costs by up to 59 per cent. Also, e-commerce has been found to yield productivity gains of 6-15 per cent for MSMEs (APEC Business Advisory Council, 2018).

10 Blockchain can enable MSMEs to access trade finance by enabling firms to build a credit history as well as facilitating transactions on a peer-to-peer basis without the need to secure traditional trade finance through the banking system (Ganne, 2018).

environment that favours lead firms on global markets (OECD, 2017b). As such, enabling access to digital technologies may not be enough. Rather, systematic policy interventions are necessary to develop a conducive environment that allows MSMEs to seize opportunities created by new digital technologies.

For low- and middle-income countries, it is increasingly clear that to capture the "digital dividend" (World Bank, 2016) and reduce the potential risks, a strategic approach to industrial development is required by building and strengthening digital skills, organisational capabilities and creating opportunities for new business models (Andreoni & Anzolin, 2019). The impact of Industry 4.0 on developing countries depends not only on available technological (and production) capabilities, but also on the pattern of specialisation and the governments' upgrading strategies and policies across sectors. At the very least, the effective adoption of these technologies is highly dependent on enabling infrastructure, such as reliable electricity and connectivity.

Before we discuss how one specific country (Morocco) engages with the challenges and opportunities offered by digital transformation in manufacturing (see Section 5), in the next two sections we delve deeper into two very different sectors in terms of labour and technology intensity (i.e. automotive and garment) in order to better understand how advanced manufacturing technologies are affecting production, trade and needed capabilities.

3 Digital transformation in the automotive sector

The automotive sector is currently undergoing a period of market turbulence and rapid technological change (Arcidiacono & Schupp, 2020). For industries producing technologically complex products and services, such as the automotive sector, the outsourcing of low-skill tasks for cost-reduction purposes has stopped being a main strategy for gaining competitive advantage. Rather, regionalisation (concentration of value chains in local and regional networks) has been more evidently driven by the needs of global innovation sectors (i.e. automotive, computers and electronics, and machine building) to "closely integrate many suppliers for just-in-time sequencing" (Lund et al., 2019, p. 9). At the same time, however, the industry faces pressures to reduce costs and maintain high quality standards (Arcidiacono & Schupp, 2020) as well as high uncertainty regarding, for instance, which drive technologies will prevail in the race to transition towards e-mobility (Verband der Automobilindustrie, 2020).

The automotive sector has been at the forefront of adopting digital technologies and automation in the production process. Since the 1960s it has progressed from simple mechanisation to industrial robotics, digital automation and presently to robotic automation. More recently, Industry 4.0 technology applications have been developed, implemented and deployed in this sector, such as the development of "smart factories", in which logistical systems are digitised, connected and streamlined, sensors are used in assembly lines, and production is based on sophisticated human–machine (robot) interactions (Lichtblau et al., 2015; Meil, 2020, p. 26). The level of robotisation in Western Europe, for instance, is highest in the automotive sector, and it is increasing also in the European Union (EU)'s new member states as labour costs rise (Drahokoupil, 2020). But the deployment of such technologies has not been uniform across locations. Yet, as competitive pressures and labour costs increase, and as the high-income countries increasingly seek to concentrate on e-

mobility solutions, OEMs and Tier 1 suppliers[11] are in the process of undergoing major transformations themselves (Drahokoupil, 2020).

In spite of their wide potential for the sector and the vast literature on expected future impacts (especially in terms of supply chain re-organisation) (Dachs et al., 2017; Drahokoupil & Fabo, 2020; Drahokoupil, 2020; Gaddi, 2020; Krzywdzinski, 2017; Pavlinek, 2018, 2020; among others), the extent of use and current implications of Industry 4.0 technologies in the automotive sector (at OEMs and their suppliers, at the sectoral and regional levels) as well as their impact on firms' (operational and economic) performance and on jobs and skills remain understudied.

While the use of industrial robots is often better classified as Industry 3.0 (i.e. automation of manufacturing), Industry 4.0 adds in technological sophistication, as it increases digitalisation of the production process (Lichtblau et al., 2015). Data collected and analysed through these digital tools are key, for instance for so-called predictive maintenance (i.e. smart monitoring), allowing operators to detect the appearance of anomalies on machines and anticipate breakdowns, or for digital production planning and inventory management.

General Motors (GM) (and other OEMs), for example, has been using 3D printing technologies (also called additive manufacturing technologies) to produce component prototypes for more than three decades (Quinn, 2020). As parts production entails a complex logistics system connecting a multitude of tiered suppliers shipping components back and forth across the manufacturing ecosystem, further advances in 3D printing could reduce waste and downtime by printing more components on location at the final vehicle assembly facility (Quinn, 2020).[12] Therefore, the traditional multi-tiered production of parts is giving way to a new integrated pattern whereby some traditional parts suppliers may lose their business, as OEMs are able to print products in their factories. However, new firms may become involved in this new production system as material suppliers, software developers and next-generation machine-makers.

Groupe Renault is also extensively engaged (especially since 2016[13]) in integrating Industry 4.0 technologies in their production plants. Recently, for instance, Renault signed a partnership with Google Cloud to accelerate the digitalisation of their production facilities and supply chain as well as to increase employees' digital skills and competencies (Groupe Renault, 2020). This partnership builds on Google Cloud's experience in smart analytics, machine learning and AI, allowing Renault to improve its supply chain and manufacturing efficiency, its production quality and the reduction in environmental impact through energy savings (Groupe Renault, 2020). By now, about 8,000 robots operate in Renault's plants handling unwieldy parts (e.g. small parts) or part picking. Virtual reality is widely used to train operators, anticipate maintenance issues and conduct production line simulations that optimise processes without interrupting the flow of work. Sensors are widely used along the

11 Tier 1 suppliers work directly with OEM companies and provide what the OEM needs for assembly and manufacturing of the final product. Tier 2 suppliers are key suppliers of components to tier 1 companies in the same supply chains and do not have direct contact to the OEM. Tier 3 suppliers produce the individual parts required in the OEM's components (Tier 2 suppliers).

12 The extended delays in global logistics created by the Covid-19 pandemic experienced not only by the chip industry but also by all other sectors highly dependent on GVC networks have raised the possibility of accelerating these trends. This may lead to a shortening of supply chains also in the automotive sector.

13 In 2016 Group Renault developed its own digital platform to connect and aggregate data from 22 Group sites worldwide (representing 76 per cent of vehicle production) and more than 2,500 machines.

supply chain to track the history of the vehicle through to delivery ("full track and trace" system[14]). The Packaging Managing System tracks every parcel in real time to keep tight oversight on inventory and procurement (Groupe Renault, s.a.).

Robots, in particular, have been vital to the automotive sector by contributing to safety, quality and productivity. Aside from GM and Renault, Ford, Mercedez-Benz, BMW and virtually every other OEM uses collaborative robots (or co-bots) on their factory floors to perform tasks from car painting and welding to assembly line work (Daley, 2020) (see Box 1).

Box 1: Six factories shaping the future of automotive robotics

Rethink Robotics, located in Boston, MA, USA, provides co-bots that help with handling materials, tending to machines, testing and inspecting and even packaging finished products. Its co-bots can work with tiny parts and reach into tight places.

Rockwell Automation, located in Milwaukee, WI, USA, produced robots that provide assistance in the body shop, from installing parts and painting cars to helping with inventory management and quality control. The company also aims to contribute to automating the manufacturing of electric cars.

Kuka, located in Augsburg, Germany, produces an extensive line of robots and software for automating car-making processes. Its software is installed into prefabricated robot applications and can run everything from 3D visualisations to simulations (e.g. for BMW's seat elements). The Kuka robots can perform tasks such as welding, water-jet cutting and assembly line inspection.

Acieta, located in Iowa, USA, creates robots for assembly line automation that have a wide range of motions and the ability to perform a variety of tasks, ranging from creating automotive components (such as pumps or motors) to welding larger car body panels and smaller brackets.

Robotic Vision Technologies, located in Silver Springs, CO, USA, creates 3D vision-guided software for robots and co-bots. The Single Camera 3D (currently used by companies such as Boeing, Ford, Toyota), which is compatible with every major industrial robot, helps locate and identify different parts of an automobile in less than 0.1 seconds, increasing efficiency.

Universal Robots, based in Boston, MA, USA, created three different co-bots that integrate into an automotive production line. Mimicking the movement of a human arm, its robotic arm brings added precision to different car-making processes. The co-bots can replace human operators in jobs that are dangerous, dirty or monotonous, freeing up workers to perform more advanced and fulfilling tasks.

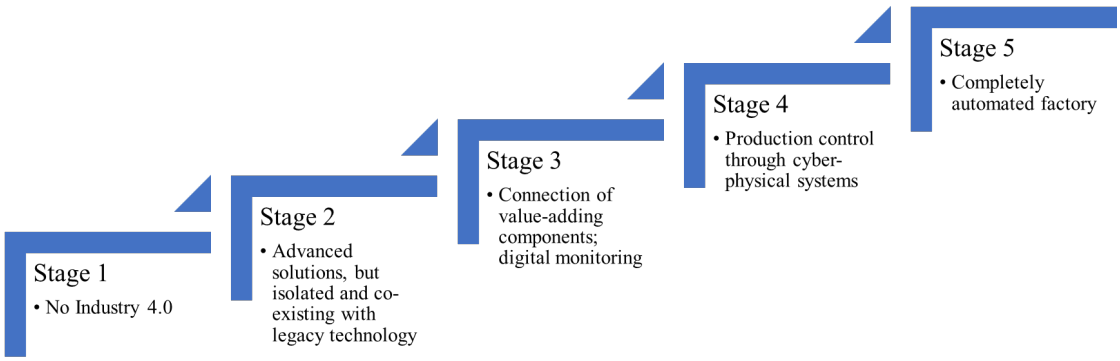
Source: Daley (2020)

Szalavetz (2020) refers to five stages of digital maturity in the automotive sector, starting with factory automation by using older generations of fenced-off robots[15] (i.e. Industry 3.0) (see Figure 2). In the second stage, more advanced solutions are introduced, but they are isolated and co-exist with legacy machinery. In the third stage, value-adding components are connected for the purpose of digital monitoring. In the fourth stage, production is controlled through cyber-physical systems. In the fifth stage, production is completely automated. Szalavetz (2020) examined the degree to which Industry 4.0 technologies are implemented in European OEMs and their subsidiaries in the Central and Eastern Europe (CEE) region, finding wide variation in digital maturity across the industry.

14 This system is already widely deployed in the aeronautics and medicine sectors. Its implementation in the automotive sector is still new, but it is expected to become more widely applied with the arrival of autonomous cars, which require traceability starting from design (Calloch, 2018).

15 As opposed to co-bots, robots were initially used in dangerous operations, such as welding, having been fenced-off for safety reasons (hence, fenced-off robots).

Figure 2: Stages of digital maturity and examples of processes and technologies



Source: Author, adapted from Szalavetz (2020)

Advanced technologies are also applied among lower-tier suppliers to OEMs, yet so far at an insufficient scale (Arcidiacono, Arcanani, Di Mauro, & Schupp, 2019; KPMG, 2016). But to fully take advantage of the value-creation potential of Industry 4.0, a uniform application of these technologies along the supply chain may be necessary (Arcidiacono & Schupp, 2020).

Several factors have been identified to affect the extent to which Industry 4.0 technologies are adopted by MSMEs that act as suppliers to OEMs and Tier 1 suppliers (see Table 2). Better understanding the extent to which these factors result in different digital maturity stages along the automotive supply chain, especially in the developing countries, would also inform policy-makers on their efforts to improve competitiveness within the sector. This is especially important since empirical evidence shows that a lack of investment in technology may represent a serious threat to lower-tier suppliers (see Gwosdz, Micek, Kocaj, Sobala-Gwosdz, & Swigost-Kapocsi, 2020, for the case of Poland).

Table 2: Examples of factors influencing Industry 4.0 adoption among MSMEs

Technological factors	IT infrastructure Existence of multiple standards Complexity linked to a variety of technologies available Availability of specialised human resources
Organisational factors	Financial constraints[16] Top management commitment Supportive organisational structure Employees' acceptance of change
Environmental factors	Price pressures from customers and power imbalance Collaboration with buyers Competitive environment Relation with technology suppliers Institutional factors

Source: Arcidiacono et al. (2019)

16 Lower-tier suppliers may not be able to finance investments in digitalisation and automation, since lower value-added activities do not bring sufficient profit to cover the investment (Drahokoupil, 2020). Low labour costs for such suppliers may therefore continue to provide an advantage for lower-tier suppliers.

Another important aspect to consider is that production networks in the automotive sector are characterised by a hierarchical structure in which multinational corporations play a major role (Barnes & Kaplinsky, 2000; Drahokoupil, 2020). Due to high levels of capital investment and skill intensity, advanced manufacturing technologies are expected to reinforce these structures (Pavlinek, 2020).[17] In such production networks, OEMs or upper-tier suppliers will most likely continue to monitor and directly control production processes in lower-tier supplier firms in order to increase efficiency and maintain quality (Gaddi, 2020). As such, most innovation is expected to stay concentrated in the core locations (at the headquarters of large OEMs) (Drahokoupil & Fabo, 2020; KPMG, 2016; Krzywdzinski, 2017; Radosevic & Ciampi Stancova, 2018), with R&D in peripheral locations being focussed on production support.

For instance, OEMs in Germany and France have located assembly and production functions in peripheral locations in CEE, Turkey and Morocco to take advantage of lower labour costs and to serve regional markets. Given the sunk costs and dependence on regional production networks, final assembly activities tend to stay in place even if labour costs rise (Drahokoupil, 2020). This is also the case for the production of bulky, heavy and more model-specific parts that may need to be concentrated close to final assembly (such as engines, transmissions, seats and other interior parts). Lighter, more generic parts can be produced at a distance and are likely to be relocated to take advantage of scale economies and low labour costs (e.g. tyres, batteries and wire harnesses) (Pavlinek, 2018, 2020).

The extent to which advanced production technologies will affect the geography of GVCs depends, therefore, on the complexity of products produced in specific locations, the labour intensity and the associated costs. Labour costs, however, are not the only determinant of automation on the shop floor. Rather, automation is often driven by requirements regarding product quality and the stability of the production process as well as by a company's internal standardisation of its production process (Krzywdzinski, 2017). To this end, for example, vocational education programmes, along with a "continuous modernisation and adaptation to economic and technological changes" (Krzywdzinski, 2017), are key. As such, low-wage countries often have varied degrees of factory automation for the same products, as evidence shows for the CEE countries and India, for example (Drahokoupil, 2020; Rizvi & Tiwari, 2019; UNIDO, 2019).

Yet, despite the massive expansion of production capacities in the CEE region and North Africa and upgrading in terms of technological modernisation of the sites, adaptation of company-wide standard production systems and the broadening of site competencies (regarding engineering, logistics, etc.), few automotive companies have built R&D units in these regions (Benabdejlil, Lung, & Piveteau, 2016; Hahn & Vidican Auktor, 2017; Jürgens & Krzywdzinski, 2009; Pavlinek, 2020). Instead, the persistent gap in labour costs, taxes and investment incentives in lower-income regions are expected to continue to attract mostly lower-value-added and labour-intensive production of standardised cars and generic components, despite the efforts of automotive companies to upgrade (Pavlinek, 2020). Yet, as we will see in the case of Morocco, there is a trend towards R&D relocation to North

17 In fact, Pavlinek (2020) shows in the case of CEE countries that large global suppliers play an increasingly enhanced role, while domestic firms are increasingly weakened within the intensely competitive automotive industry.

Africa as the local supply chain becomes more complex and the capabilities of domestic suppliers increase.

In the long term, however, the low-skilled production and assembly locations may see major transformations in terms of automation (Drahokoupil, 2020). The extent to which policy-makers in developing countries "prepare for the future" to better position themselves (by investing in building domestic technological capabilities) to take advantage of associated opportunities (e.g. in terms of gradually moving from simple to complex engineering and to R&D functions) will critically determine success in export-led manufacturing (Hallward-Driemeier & Nayyar, 2018).

For Morocco, in particular, these global sector-level trends create both challenges and opportunities. With significant progress already having been achieved (Hahn & Vidican Auktor, 2017, 2018), industrial policy-makers must ensure that technological upgrading is deepened along the entire value chain. The industrial policy strategy must be reoriented from fiscal incentives to attract investment towards creating the framework conditions for innovation, knowledge development and advanced research. Building partnerships in areas related to complex engineering, R&D and related services would ensure that Morocco can stay relevant to OEMs strongly advancing in the Industry 4.0 space. Such a focus on technological upgrading would also enable Morocco to capture new opportunities created by the relocation of production from the CEE region to North Africa.

4 Digital transformation in the garment sector

In contrast to the automotive sector, the garment sector is labour-intensive, absorbing a large share of employment in low- and middle-income countries and contributing significantly to export earnings. Automation has a longer history in the (capital and skill-intensive) textile[18] sector (e.g. in spinning, weaving and knitting) accelerated also by the introduction of computer numerically controlled (CNC) machinery (Altenburg et al., 2020). The (low-skilled, labour-intensive) garment sector is, however, a laggard in terms of adopting and developing new technologies in production, mostly because of the high upfront costs of such investments, process complexities related to the difficulty of automating the handling of cloth and the wide availability of cheap labour.

Yet, to meet higher quality requirements and the demands of lean manufacturing as well as to survive the intense competition, there is interest among garment manufacturers to increasingly use automation in production processes that previously relied on low-skilled labour. The extent to which digital innovations will make their way into the garment sector of developing countries will, therefore, have important implications, not only on employment, but also on the future pattern of specialisation.

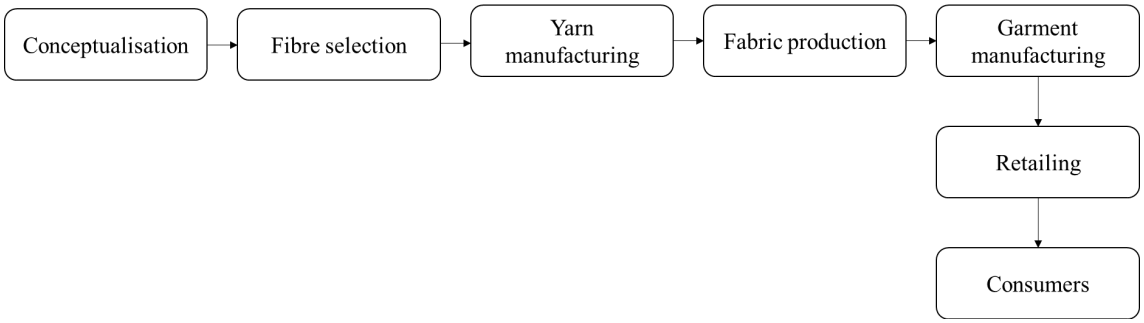
The potential impact of automation on employment may be quite large in the garment sector, especially when it comes to a change in the needed skills. While some argue that the loss of jobs in low- and middle-income countries may be significant, others claim that new jobs

18 The textile sector comprises activities such as yarn and fabric manufacturing via spinning, weaving and knitting.

will be created, particularly in engineering and machine maintenance, thus requiring a new set of skills (Link, 2020).

To understand the opportunities and challenges of digitalisation in the garment sector, it is important to break down the manufacturing process along the supply chain. The manufacturing process for a piece of clothing entails several steps (see Figure 3) that often operate in silos (Weinswig, 2017), starting from the conceptualisation and design of the item, fibre selection (which also entails sampling and raw materials sourcing), followed by the processing of fibre into yarn and fabric. Getting from fabric production to garment manufacturing entails several processes: spreading, cutting and ironing, followed by sewing, which is the most labour-intensive part of the production process (requiring two-thirds of total employment) (Altenburg et al., 2020; Chang, Rynhart, & Huynh, 2016).

Figure 3: Sequence of the garment manufacturing process



Source: Author, based on Bravo-Cadena, Monter-Olvera, Cruz-Vasquez, Martinez-Martinez and Bustos-Terrones (2019)

Automation and digital technologies can be used across the garment supply chain (Weinswig, 2017) to increase speed, quality, flexibility and use of resources. In the conceptualisation and design stage, 3D fashion design software could replace the paper-based process to reduce the time needed to move an item from design to manufacturing. In the fibre-selection stage, virtual yarnbank tools replace physical samples to support spinners, knit manufacturers and apparel companies "by eliminating the poor logistics of the trial-and-error sampling taking place across the fashion industry" and by reducing waste for a sustainable manufacturing supply chain (Textile 4.0, 2020).[19] In the production stage, machinery using digital technology (robotics for sewing and printing, sensors, etc.) could be used to increase precision and efficiency. In the distribution stage, companies can use IoT and robotics to run smoother picking and packing operations and coordinate delivery. In the retail/sales stage, in-store technology such as sensor systems may be used to track and analyse consumers' behaviour to improve sales. All these technologies also open opportunities for new, innovative business models relying on e-commerce.

Given the high share of labour-costs in garment manufacturing and the increasing discussions on reshoring and nearshoring, interest in automation has increased especially among firms in early-industrialising countries seeking to expand domestic manufacturing

19 An example of such solutions is Shima Seiki, a provider of web solutions for the textile industry (Textile 4.0, 2020).

(Textile 4.0, 2020). Robotics, for instance, has also been increasingly used in pressing fabric. Yet, the extensive deployment of automation and robotics has been challenging, especially in sewing operations, "due to the limpness of fabrics, the frequent need for manual pulling and slipping of material, and the complexities of the non-linear needle-fabric interaction during sewing" (Altenburg et al., 2020, p. 12). Thus, global robot sales to the textiles/clothing industry remain extremely low relative to other industries such as automotive.[20]

Aside from robotics, however, other digital innovations have made their way into the garment sector, such as lasers for cutting fabric[21] (see also Nayak & Padhye, 2018), "direct-to-textile" 3D printing technology, body scanning technologies and "smart textiles", referring to an increasing use of sensors and monitoring devices for technical textiles. Altenburg et al. (2020) present a range of new and potentially disruptive digital technologies that are being used in clothing and footwear manufacturing. These solutions range from automation and robotics in sewing to additive manufacturing and digital imaging for laser robots, all aiming to shift from traditional means of production to customisation and on-demand apparel manufacturing.[22]

Yet, most of these technologies are far from commercialisation and large-scale deployment.[23] Garment manufacturers still find it advantageous to outsource labour-intensive production. Additive manufacturing (3D printing) in the design of garments and the printing of fabric (replacing digital textile ink printers) is gaining in popularity (Textile 4.0, 2020). Yet, the market for such technologies remains small due to "expensive equipment, elongated production times, and somewhat small, impractical and expensive range of clothing" they can manufacture (McMullen, 2020). In addition, as Altenburg et al. (2020) conclude, digitalisation in the garment sector is still in an "era of ferment" where various technological solutions/designs are competing.

Therefore, the risk that advanced automation will displace low-skilled workers in the garment sector in low- and middle-income countries remains low during this period of technological experimentation and uncertainty (Hallward-Driemeier & Nayyar, 2018;

20 In 2018 only 1,268 multipurpose industrial robots were used in Germany per 10,000 people employed in the automotive industry (Drahokoupil, 2020). Altenburg et al. (2020) refer, instead, to global sales data (443 robots in the entire textile/garment sector).

21 For example, Zund, a large Swiss cutting-solutions company, has developed recently a digitalised software product, The MindCUT Studio, aimed to "multiply design options, streamline processes and increase flexibility in digital textile cutting". "Using powerful nesting algorithms, the visual data the machine collects is applied to Zund's state-of-the-art cutting solutions to make sure the most accurate cuts are made, minimising wasted material and energy. The Studio also monitors the life cycle of the machinery parts, notifying customers when parts may need changing to reducing downtime for cutting machines." Gerber Technology has also recently launched the Atria digital cutting room, leveraging Industry 4.0 and IoT connecting the entire mass production process, from CAD to the cut room (Textile 4.0, 2020).

22 Another example, TamiCare, a UK-based manufacturer, uses 3D technology to print garments from scratch. Their process claims to cut out spinning, weaving, processing and dyeing from the value chain, "taking anywhere between seconds and minutes to create a garment" (Textile 4.0, 2020).

23 Aside from the cost of investment and the availability of low-cost labour for manufacturing, another reason why, for instance, additive manufacturing technology is not widely deployed relates to the difficulty of post-processing of printed components, which currently is still being done mostly manually (Textile 4.0, 2020).

WTO, 2018). Empirical evidence suggests that this window of opportunity for automating sewing is at least 15-20 years (Altenburg et al., 2020). This is not the case, however, for simple garments such as t-shirts, where robotics may replace traditional labour-intensive production processes by 2025 (Andersson et al., 2018).

The great variation in terms of labour intensity and automation difficulty between different product and design types makes it challenging to draw a concluding argument. The differences relate to various product characteristics, such as the number of pieces, finishing and intricate details, movement of parts and the types of raw materials (Andersson et al., 2018). In addition, product lifecycles and degree of fashionability (meaning conformity to fashion trends) are also important determinants of the relevance of short lead times (which would impact nearshoring decisions) and "agility for higher sell-through rates and increased sales" (Andersson et al., 2018, p. 25). All these elements combined affect the likelihood of nearshoring for different types of garment products.

Therefore, policy-makers in low- and middle-income countries should take advantage of this open window of time to position themselves such that they can harness opportunities from upgrading in the garment sector. In the garment sector, automation gradually increases along the entire value chain (less so in the sewing process) and even more products (e.g. T-shirts, knitwear) can be entirely automated. Therefore, the niche where labour-cost advantages still matter is shrinking and will probably disappear within 10-15 years, as mentioned earlier (Altenburg et al., 2020). Therefore, this time span needs to be used to introduce partial automation (as China and other Asian countries have been doing)[24] and to reduce the time-to-market as well as improve IT integration with the point of sale to be able to serve the ever-shorter and more customised fashion cycles. Therefore, improving capabilities (both for workers and firms) to adopt and use new or mature digital technologies is critical to achieve success in manufacturing (Hallward-Driemeier & Nayyar, 2018).

Yet, most low- and middle-income countries are still lagging behind in terms of wide dissemination, even when it comes to Industry 3.0 technologies. If automation of production is to be expected only in the long run, the wider adoption and use of digital technologies further upstream and downstream the supply chain may play a much more important role in the short and medium terms, opening up opportunities also for productivity improvements and market expansion (WTO, 2018). Given the prevailing "digital capability gap" between Industry 4.0 "company islands" (Andreoni & Anzolin, 2019, p. 6) and suppliers, even a more extensive use of (basic) ICT technologies, a shift to e-commerce platforms and the use of data analytics, cloud technology or smart logistics could help producers respond more quickly to customer demand, produce according to higher quality standards and reduce risks.

Morocco and other countries in the North African region could indeed capitalise on the opportunities created by the nearshoring of production to take advantage of new business models that capitalise on reducing the time-to-market and customised products. Full automation in the garment sector may be more viable for markets targeting mass production, such as China and other countries in Africa.[25] Given these trends at the global and sectoral levels, the industrial development strategy of Morocco would, however, look very different

24 Interview with Dakota, January 2021.

25 Interview with Gerzi, July 2021.

in comparison with the automotive sector. For the apparel sector, policy-makers would have to first ensure that basic technological (and digital) capabilities are strengthened within the large group of MSMEs. Moreover, given the fast-changing dynamics – accelerated especially by the Covid-19 pandemic – building knowledge on new business models driven by changing GVCs and technological developments would be necessary, even for industry associations to better guide their members. Furthermore, investment in education and aligning vocational training would be much more important in this sector at this stage to ensure that newly demanded skills are necessary. The conventional industrial policy tool-box of incentives for capital investments and attracting foreign investors would also be essential.

5 Fostering industrialisation in Morocco through advanced manufacturing technologies

The technological trends discussed above are expected to have sizeable implications on the industrial development trajectory of low- and middle-income countries. In this section we delve deeper into the specific way in which Morocco engages with these new technologies related to digitalisation and advanced manufacturing. First, in Section 5.1, we discuss the national industrial development strategy, followed by an overview of the government's efforts to increase the use of digital technologies in the economy. In Sections 5.2 and 5.3, we turn our attention to the automotive and garment sectors, respectively. Here we discuss the current development strategy for the sector in light of global and sectoral technological developments, the level of readiness to engage with these technologies, and the opportunities and challenges that technological upgrading along the supply chain create.

The analysis draws on desk research and 35 interviews with diverse stakeholders in the private sector, academia and research as well as policy-makers in Morocco and abroad. First, 11 interviews with policy-makers and industry associations were conducted in Morocco (between January and February 2020) to better understand the objectives to be included in the upcoming industrial development strategy and the new national digitalisation agenda. Second, further interviews with industry experts, policy-makers, researchers and academics in Morocco and abroad were conducted online (due to the Covid-19-related travel restrictions) between January and July 2021. Primary data from the expert interviews was supplemented with data collected during participation in several online conferences and webinars (see Annex), and through consulting various industry reports and academic literature.

5.1 Industrial development strategy and degree of readiness

Morocco's industrial development process has seen a major turning point, especially since 2005. At the time, under the framework of the so-called National Pact for Industrial Emergence, extensive effort has been made to attract investment, foster upgrading and increase the integration of Moroccan firms into GVCs. This effort was continued in the 2014-2020 Industrial Acceleration Plan (PAI), when a focus was placed on identifying sectors and sub-sectors (so-called ecosystems) with high value-added potential and opportunities for expanding Morocco's engagement in global markets. While these developments have been examined at length elsewhere (see, for example, El Mokri, 2016;

Hahn & Vidican Auktor, 2017, 2018), it suffices to say that this systematic approach to industrial development aimed at increasing the country's role on global markets makes Morocco's case worthy of further examination.

This drive for finding venues to accelerate structural transformation towards greater value-added as well as higher technological content and employment has led policy-makers to explore further economic opportunities not only "north" from Morocco into Europe, but also to further expand its role on the African continent. The strengthening of Morocco's partnership with other African economies has become a major political strategy as it aims to become a major knowledge hub in several sectors, including energy and automotive, and link the EU with African markets (Ghazi & Oualalou, 2021).

These efforts converged under the overarching goal of King Mohammed VI to find a New Development Model (NDM) for Morocco, an idea he put forward in 2017 in preparation for the industrial development strategy post-2020 (Conseil Economique, Social et Environnemental [CESE], 2017). The new industrial strategy should, in particular, aim for accelerating industrialisation in an "agile, solidary and inclusive" way (CESE, 2017) while responding to global challenges and dynamics related to the low-carbon transformation and rapid technological developments, better governance, accelerating job creation and strengthening social inclusion.

Following the launch of these new strategic development objectives, ministries and their relevant stakeholders were called upon to reassess their current targets, sectoral and regional strategies, and propose new (and collaborative) solutions to improve competitiveness, attract investments, reduce regional and income inequality, and more importantly, create jobs. The much-awaited NDM, which is expected to lay the ground for a new development paradigm for Morocco, was published in April 2021 (Royaume du Maroc, 2021). The NDM appears, however, to bring little new in terms of its approach to industrial development and ambition. Moreover, its engagement concerning critical governance issues that have been hindering growth for decades has been very limited (Akesbi, 2021), issues such as rent management, corruption, high levels of inequality and the privileged status of elite-driven companies. This raises doubts that the needed transformative changes will materialise in the coming decade.

As expected, two cross-cutting and pertinent global economic development themes for the 21st century – green growth and digital transformation – have been prominently integrated into Morocco's search for a new development strategy. These aspects have also been seen as core pillars of the second stage of PAI (so-called PAI 2.0) for the period 2021-2025.[26] The new industrial development strategy (not yet entirely finalised and publicised) aims to consolidate the achievements made so far, increase coherence across regional development plans, increase the integration of MSMEs in GVCs, and – through research and innovation – upgrade the industrial sector in terms of technology (Hatim, 2020). However, the disruptive effects of the Covid-19 pandemic since February 2020 have delayed the finalisation of the new industrial development strategy. As such, by June 2021 only a roadmap to 2022 has been communicated internally to other ministries by the Ministry of Industry, Trade, Investment, and the Digital Economy (hereafter Ministry of Industry).[27]

26 Interview with the Ministry of Industry, January 2020.

27 Interview with the Ministry of Economy and Finance, February 2021.

More specifically, PAI 2.0 aims to centre[28] on upgrading in key sectors, attracting investment, building specialised corridors based (more or less) on regional comparative advantages and resources, job creation and developing new niche entry markets/ investment opportunities for technology-intensive products (e.g. batteries for sustainable mobility). The focus is thus both on labour-intensive sectors (specifically textile and garment) and technology-intensive sectors (i.e. automotive and aeronautics).

Two other issues have been mentioned to be at the core of PAI 2.0: promoting innovation and reforming vocational training. Fostering innovation is seen to be important in the strategic sectors of automotive and aeronautics. "Technology ecosystems" are being targeted, such as autonomous and electric cars, aeronautics, digital technologies (and digitalisation more generally)[29] and drones. A reform of the training system is also considered necessary, given the large gap between the supply and demand of skills. Cooperation between the main training stakeholders (the National Agency for Promotion of Employment and Skills (ANAPEC) and the Office of Vocational Training and Employment Promotion (OFPPT)) and the National Agency for the Promotion of Small and Medium-sized Enterprises (MarocPME) is supposed to re-design and regionalise the vocational training institutes, modelling them on the successful private-sector-led training centres of the automotive, aeronautics, textile and garment sectors.[30]

A major pillar of the NDM is accelerating digital transformation in Morocco by expanding digitalisation and fostering innovation, both within the public and private sectors. This goal is well articulated in the government's strategy Maroc Digital 2020,[31] which seeks to reinforce Morocco's role as a regional digital hub, enhance digital skills and digital governance, and increase the adoption of digital technologies across sectors. In spite of various structural challenges,[32] progress in this direction has accelerated, especially following the start of the Covid-19 pandemic.[33] By 2020, Morocco was still lagging behind on some indicators that are important for the digitalisation of the economy, relative to the Middle East and North Africa (MENA) region, especially when it comes to the legal framework's adaptability to digital business models, which may hinder e-commerce, adequate training and infrastructure (i.e. knowledge and infrastructure pillar), and extreme differences between the rural and urban use of digital payments (highlighted in blue in Table 3 below).

28 Interview with the Ministry of Industry, January 2020.

29 Too generally discussed in our meeting to see exactly what the Ministry seeks to focus on for the next phase of the industrial development strategy.

30 Interview with GIMAS and the Ministry of Industry, January 2020.

31 Maroc Digital 2020 follows the less ambitious Maroc Numeric 2013 strategy.

32 More needs to be done to improve the digital economy in Morocco in terms of facilitating access to "digital banking and financial services, improvement of telecommunications networks and digital coverage, and raising awareness of the digital technologies among citizens across the country, massive investments in IT infrastructure and real economic reforms" (Guerraoui, 2019).

33 Interview with AMITH, February 2021; Interview with APEBI, June 2021.

Table 3: Selected indicators related to digitalisation across North African countries and relative to MENA and the EU

	MOR	ALG	TUN	EGY	MENA	EU
Digitalisation Index	0.38	0.00	0.33	0.34	0.46	0.60
Institutional and regulatory						
Government Online Service Index	63.08	13.08	78.47	48.46	62.36	82.66
Legal framework's adaptability to digital business models	43.51	32.07	33.00	38.16	55.34	54.38
ICT regulatory environment	89.77	58.50	73.75	80.89	72.55	93.15
E-commerce legislation	100.00	50.00	100.00	50.00	71.88	100.00
Ease of doing business	73.40	48.60	68.70	60.10	61.60	76.20
Human capital						
Enabling digitalisation – knowledge pillar	33.90	38.30	26.70	55.90	51.70	65.50
Firms (both large and SMEs) with website	65.94	n/a	61.92	42.97	48.86	76.12
Share of Internet users in total population (%)	64.30	58.00	66.80	48.10	70.93	88.22
E-Participation Index	74.52	9.55	88.07	47.77	60.17	84.22
Socioeconomic gap in use of digital payments	30.05	60.38	35.33	37.66	58.17	87.03
Infrastructure						
Enabling digitalisation – connectivity pillar	66.50	28.40	58.70	45.50	50.80	61.90
Enabling digitalisation – infrastructure pillar	31.40	32.90	36.40	28.40	52.30	73.20
Availability of local online payments	51.41	39.43	39.46	57.52	57.29	72.65
Rural gap in use of digital payments	0.00	89.99	27.44	53.11	51.63	72.90

Source: Author, adapted from Sidlo, Karunska, Salmeri, Bieliei and Albinyana (2020). The Digitalisation Index is provided on a scale from 0 (worst performance) to 1 (best performance). The rest of the scores are provided on a scale from 0 (worst performance) to 100 (best performance). Data is sourced from Camara and Tuesta (2017), Euler (2018), and Portulans Institute and WITSA (2019).

The implementation of the Maroc Digital 2020 strategy has been assigned to the Agency for Digital Development (ADD), which was created in 2019. On economy-related issues, ADD is accountable to the Ministry of Industry. At the time of our interviews in 2020, the responsibilities and scope of action for ADD were not entirely clear, having under its umbrella a variety of projects that would require close coordination with other stakeholders and clear political support for the required inter-ministerial cooperation (for instance in data collection and sharing), such as from the politically strong Ministry of Interior. On economy-related issues, the objective is to develop projects that support an increase in productivity and competitiveness in key sectors such as textiles and garment and food processing, and to enable further upgrading in more advanced/complex sectors such as automotive and aeronautics.[34]

34 One problem is that, as seen in our interviews with ADD in January 2020 and later in discussions with other stakeholders in 2021, the decisions about which projects to initiate, in which sectors and supporting which technologies have been based on a very general survey with a narrow group of firms (113 firms across the entire economy).

A key focus of PAI 2.0 is to enable MSMEs to enhance their competitiveness in export markets as well as support lead firms/sectors in augmenting their technological capabilities by engaging with Industry 4.0 technologies (e.g. smart automation, advanced robotics, 3D printing, IoT).[35] A challenge, however, is reducing the risks related to the potentially negative effects on job creation and taking advantage of opportunities associated with new sources of knowledge, export markets, and jobs in production and services.

ADD's main project in this area is the set-up of a so-called Smart Factory in Fez, where public and private investments have been made to build an innovation cluster in close cooperation with the Euromed University of Fez (UEMF) (created in 2012). The Smart Factory is supposed to be a solutions-oriented lab (a showroom), where MSMEs can test different Industry 4.0 solutions to improve awareness across firms and encourage uptake. Collaborations between universities, research institutes and the private sector should be at the core of the Smart Factory. In January 2020 public funding of €2 million was approved for this project. The developer of this concept (appointed in January as head of the Federation of Information Technology, Telecommunications and Offshoring Industry (APEBI),[36] the industry association for the ICT and offshoring sectors) has been seeking international technology suppliers (in IoT, robotics, AI, cloud) to, ideally, set up research facilities/collaborations in the Smart Factory.[37] The sectors being aimed at by the Smart Factory are primarily electronics and electrical equipment, agro-food, automotive, and textile and garment. By 2021, as per various interviews, the project seems to have stalled or encountered delays, also because of the special Covid-19 circumstances.

By mid-2021, the Ministry of Industry and ADD presented the new strategy Pact Maroc Digital for the period 2021-2025 to selected stakeholders.[38] A core element of the strategy is enabling digital transformation in the industrial sector while aiming to build capabilities in order to both "consume and produce" technology.[39] Two key pillars comprise the focus of the Pact Maroc Digital: (1) a technology ecosystem dedicated to building capabilities in key Industry 4.0 technologies (AI, cybersecurity, IoT, embedded systems, 3D printing, etc.),

35 Interview with Ministry of Industry, January 2020.

36 A side note, but quite important on the ICT and offshoring sector (a strategic sector of PAI): APEBI, the industry association, is currently under major reorganisation after new directors were elected in January 2020. Specifically, a major problem is that no oversight of its members (regarding activities, size, capabilities) exists, in spite of its growth and increase in investment in the last years. Thus, a large effort will be made to understand the firms that are part of the sector, what services they offer and what capabilities exist. An "observatory" will be created to collect and aggregate such data from members. Second, the larger MSME sector is unaware of the benefits that ICT can offer for upgrading and reaching export markets, which is the reason why a road show is planned (Digital for All) to engage with firms in different sectors and explain the benefits that different ICT (and more generally digital) technologies can offer. Third, upgrading skills in ICT technologies at all levels of schools (Skills for All) including retraining and professional training. Forth, positioning Morocco as a technology leader in Africa. An update on these planned activities in 2021 was not possible due to difficulties of reconnecting with APEBI.

37 As per our interviews with APEBI in January 2020, it will take at least two years for this project to take off (facilities have to be built, the concept further developed and implemented, and public-private partnerships and funding be obtained).

38 Interview with APEBI, June 2021.

39 Interview with APEBI, June 2021.

and (2) technology application ecosystems (agri-tech, food tech, e-commerce, gaming, fin-tech, health tech).[40]

While at the national level the urgency to enable the digital transformation has been recognised and the initial strategies to support action at different levels and across sectors have begun, several prerequisites are missing, and therefore the level of readiness remains low, especially in the MSME sector. Insufficient access to ICT and a lack of digital literacy are among the challenges, in spite of recent improvements.[41] To this end, the MarocPME – the main operational instrument for MSMEs – has initiated various programmes[42] to both support innovation and the start-up ecosystem and to encourage digitalisation across sectors.

5.2 Prospects and challenges in the automotive sector

The automotive sector has been the star performer of Morocco's industrialisation strategy over the last decades. Renault's decisions to invest in Morocco in 2003 and further upscale its investments in 2013 were critical to enabling the local industry's integration into GVCs (Hahn & Vidican Auktor 2017, 2018). These initial developments also attracted other investors and a range of suppliers to local operations in Morocco. A proactive industrial policy strategy aimed at upgrading, localising manufacturing and systematically increasing value added along the supply chain has also contributed to increasing exports, knowledge transfer and employment (Hahn &Vidican Auktor, 2018; Hakam, 2020).

Over the years, the automotive sector has become strategically important for Morocco and a prominent actor in the automotive industry regionally and in Africa,[43] with an installed capacity of 700,000 vehicles per year (Naji, 2020). Currently more than 400,000 vehicles are being produced, with a localisation rate of 60 per cent (Kanouni, 2020). Exports increased by almost 15 per cent per year and doubled between 2013 and 2018, while employment – currently at 189,000 workers – increased by adding 116,600 jobs since the launch of PAI in 2014 (Kanouni, 2020). Around 80 per cent of the vehicles produced are destined for the European markets, mainly France (31 per cent), Spain (11 per cent), Germany (9 per cent) and Italy (9 per cent) (Kanouni, 2020). In 2019 export revenues from the automotive sector represented 25 per cent of Morocco's total exports (Kanouni, 2020).

The presence of two large OEMs – Renault-Nissan leading the cluster around Tanger Automotive City, and the PSA Peugeot Citroën[44] leading the newly formed ecosystem in Kenitra – has catalysed additional investments in the sector, where more than 250 equipment

40 Interview with APEBI, June 2021.

41 In particular, Morocco ranks below the MENA average when it comes to ICT adoption, skills and innovation capability (World Economic Forum, 2019).

42 Examples of such programmes are: TATWIR Croissance verte (for green innovation), TATWIR Startup (incubation programmes for innovative solutions for the industry), NAWAT (for micro enterprises and freelancers), ISTITMAR (financial support for MSMEs for upgrading investments), MOWAKABA (capacity-building programmes for MSMEs seeking to improve their competitiveness).

43 Morocco has become African's largest automaker after South Africa, and the first passenger car manufacturer on the continent (Kanouni, 2020).

44 The PSA Groupe comprises Peugeot, Citroen, DS Automobiles, Opel and Vauxhall.

manufacturers provide a complete supply chain for the OEMs (Kanouni, 2020). While most of the Tier 1 and 2 suppliers have followed the OEMs to Morocco, Moroccan firms are increasingly acting as Tier 2 and Tier 3 suppliers, while a few, such as Alten, also act as Tier 1 suppliers. BYD, the Chinese global e-mobility powerhouse, also signed a memorandum of understanding with the Moroccan government in 2017 to set up operations there. Yet, the BYD deal has been mired in delays, and the outcome remains uncertain (Tanchum, 2021b).

OEMs and leading Tier 1 suppliers find Morocco an attractive investment location for several reasons:[45] political stability, labour costs, infrastructure system (roads, shipping, energy),[46] proximity to Europe (i.e. transit time), fiscal and investment incentives, engineering and mid-management skills. The visionary industrial development strategy, highly focussed on upgrading in the automotive sector, has been widely recognised by the interviewed stakeholders to have contributed towards making Morocco a key destination for companies in the automotive sector.

The two main OEMs in Morocco are Renault-Nissan and Stellantis N.V. (hereafter Stellantis) (previously the PSA Group). The Renault-Nissan plant in Tanger is the largest automobile plant in Africa. The factory runs two production lines covering everything from stamping to assembly, sheet metal work, painting, seats and chassis. It produces the Lodgy, Dokker, Dokker Van, Sandero and Sandero Stepway models.

The PSA Group started in Morocco in 2019 with an annual production capacity of 100,000 vehicles, aiming to double its capacity before 2023 and currently providing 3,000 direct jobs (Stellantis, s.a.) (and aiming for 20,000 indirect jobs by 2023). More recently, in 2022, a new agreement has been signed with the Ministry of Industry aiming to triple Stellantis' capacity in Morocco by 2025.[47] The PSA Group merged in January 2021 with Fiat Chrysler Automobiles N.V., becoming Stellantis (2021). Stellantis has built a complete industrial ecosystem in Kenitra, including capabilities for internal combustion engines and electric vehicles for both the domestic and regional markets, acting as an export platform for Africa and the Middle East. Following the investments of Stellantis, at least 28 investors have already settled in the Kenitra Automotive City free-zone area (launched in 2019) and 22 others in the Tanger Automotive City zone (Naji, 2020). Stellantis has also built a design and engineering R&D centre (the Morocco Technical Center), currently employing 2,500 engineers and senior technicians (Ministry of Industry, s.a.-a). Since Stellantis' strategy has been the integration of the entire supply chain in Morocco, building up R&D capabilities locally has been seen to be essential, especially because Stellantis announced in September 2021 that Opel, one of its carmakers, will build the first electric car factory (for its Rocks-e model) in Morocco (in Kenitra), giving Morocco's automotive industry an important first-mover advantage in the region, "leapfrogging China's plan to build electric cars in Egypt"

45 Workshop with key German suppliers such as Pretl, FEV, Stahlschmid (23 September 2021); Interview with Renault, April 2021.

46 Morocco's al-Boraq high-speed rail line – the first of its kind in Africa – is the transport backbone of Morocco's Africa-to-Europe value chain. With the 2018 inauguration of its first segment connecting Tangier to Casablanca, the Boraq line is linked to Morocco's new state-of-the-art Tanger Med port on the country's Mediterranean coast 40 km east of Tangier. Upon the completion of the port's June 2019 Phase Two development, Tanger Med became the Mediterranean's largest port with a total container capacity of 9 million 20-foot equivalent units, surpassing Spain's Algeciras and Valencia ports (Tanchum, 2021a).

47 Interview with Ministry of Industry, January 2022.

(Tanchum, 2021b). The Rocks-e model was developed at the R&D Morocco Technical Center set up by Stellantis.[48] The decision is seen as a strategic step towards being able to develop a production base for the cost-effective export of electric vehicles, initially for major European cities (i.e. in Germany from autumn 2021) to later expand to markets in sub-Saharan Africa (especially to the West African markets) (Tanchum, 2021b).

A diversification of the automotive sector in Morocco into electric vehicles has also been supported by the European (French-Italian) semiconductor manufacturer STMicroelectronics' recent inauguration of a microchip production line for electric vehicles for Tesla in its Bouskoura plant on the outskirts of Casablanca (Tanchum, 2021a). This strategic decision on location aims to alleviate critical global shortages of automotive microchips, thereby supporting electric vehicle automakers to maintain production schedules (Tanchum, 2021a). The early stages of chip production in Morocco also raise the prospects that Renault may shift its Dacia Spring EV electric car manufacturing from China to Morocco (Tanchum, 2021a). In addition, although Stellantis manufactures its new Peugeot e-208 electric vehicle in Slovakia, later on it could also be assembled in the Kenitra plant since the chassis is the same one used in the petrol-powered Peugeot 208 (Tanchum, 2021a). Therefore, the nearshoring of global supply chains may significantly favour Morocco's automotive sector due to the favourable conditions listed earlier. Prettl Automotive, a key Tier 1 and Tier 2 supplier of products and solutions for OEMs such as Bosch and Continental, has also signed an agreement to produce and assemble e-bikes in Morocco to export to Africa and Asia.[49] Moreover, FEV argues that engineers specialised in tests and validation processes for e-mobility are already working in Casablanca.[50]

The Covid-19 crisis has had an impact on the automotive industry, not only globally but also in Morocco. Disruptions in regional and international supply chains led to a standstill for the OEMs over several weeks, following difficulties in sourcing parts and components. This placed additional pressures on major suppliers to satisfy their orders.

5.2.1 Policy framework and key stakeholders

Foreign investment continues to increase and is primarily driven by the existing industrial base and know-how, government support (such as tax exemptions for the first five years, value-added tax (VAT) exemptions and land purchase subsidies), a skilled workforce and infrastructure. Table 4 summarises the main instruments used to incentivise investments and upgrading in the sector. As most interviewees mentioned, the incentives offered "are more than enough", and there is little more that the government can do without breaking the World Trade Organization's rules for free trade.[51] In addition, the four specialised Automotive Industry Training Institutes (IFMIAs) are also contributing to attracting manufacturers and local firms to enter the sector.

48 MTC's improved design of Rocks-e has helped Opel to minimise production costs to reduce the retail price of the Rocks-e to possibly as little as $7,000 (Tanchum, 2021b).

49 Prettl Automotive speech at the AHK Business Talk: Automotive workshop on 23 September 2021.

50 FEV speech at the AHK Business Talk: Automotive workshop on 23 September 2021.

51 Interview with TE Connectivity and Alten Maroc, June 2021.

Table 4: Government assistance and support for firms in the automotive sector in Morocco	
Area of intervention	**Instruments**
Investment promotion	o 275 hectares of rental property reserved for the sector, of which 95 hectares are already committed. o The Investment Promotion Fund (IPF) covers up to 20 per cent of the cost of the land, up to 5 per cent of the total amount of capital investment or 10 per cent in case of an investment in the sector of spinning, weaving and finishing, as long as the investment represents at least 200 million dirhams over a three-year period, creates a minimum of 250 stable jobs over three years, ensures technology transfer and contributes to the protection of the environment. o The Hassan II Fund offers grants of up to 15 per cent of the purchase of used equipment imported and intended for stamping, plastic injection, or to be used in the manufacture of tools and moulds (excluding any other state contribution paid for the acquisition of capital goods). The total amount of the investment (excluding export duty and tax) must be 10 million dirhams or more, and the investment in goods and equipment must be 5 million dirhams or more. o One-stop service for investors.
Export promotion	o Exemption of import duties on capital equipment, materials and tools necessary for the implementation of an investment project with a total cost greater than 200 million dirhams during 36 months after the signing of the investment agreement. o Simplified customs procedures. o Exemption from VAT on imports of capital equipment, materials and tools necessary for the implementation of an investment project with a total cost greater than 200 million dirhams until 36 months after the start of activity. o Unlimited exemption from VAT in respect to products delivered and services supplied to the free export zones.
Tax incentives	o The exemption from import duty on capital equipment, materials and tools necessary for the implementation of an investment project with a total cost greater than 200 million dirhams during the 36 months after the signing of the investment agreement; this exemption is extended to parts, replacement parts and accessories imported at the same time as the aforementioned equipment. o The exemption from VAT on imports of capital equipment, materials and tools necessary for the implementation of an investment project with a total cost greater than 200 million dirhams until 36 months after the start of activity by the company or from the date of issuance of the building permit, and which may be extended by six months in the event of force majeure (renewable once); this exemption is extended to parts, replacement parts and accessories imported at the same time as the aforementioned equipment.
Free trade zones (FTZs)	o Tanger Automotive City; Atlantic Free Zone, Kenitra Automotive City o Exemptions associated with the FTZs: income tax during the first 5 years; reduction of 80 per cent of tax on gross earned income during the following 20 years; corporation tax for the first 5 years and then a rate of 8.75 per cent for the following 20 years; professional tax for the first 15 years; urban tax for the first 15 years; participation in national solidarity; income from corporate rights, dividends and similar income for non-residents, and a reduction in tax to 7.5 per cent for residents.
Training	o Training programmes tailored to the needs of the sector through four training centres covering 90,000 profiles. o IPF covers up to 20 per cent of the cost of training.
Source: Author, based on information from the Ministry of Industry (s.a.-a)	

The Moroccan Automotive Industry Association (AMICA) has played a critical role in the development of the sector by taking a coordinating role between the firms with the Ministry of Industry, identifying the needs for upgrading and attracting investment in key segments along the supply chain (Hahn & Vidican Auktor, 2017). More recently, as the Moroccan industry has reached a certain degree of maturity, the local OEMs often act on their own to attract suppliers and negotiate their interests and training needs with the Ministry of Industry.[52] Still, AMICA, together with the Moroccan Agency for Investment and Export Promotion (AMDIE), is a major catalyst for achieving higher levels of upgrading in the automotive sector as well as providing perspectives on needed investments in weaker ecosystems, skill development programmes and investments in R&D.

AMICA, through its proactive and pragmatic approach, guided the development of training programmes targeted directly to the needs of firms. As such, already in 2009, IFMIAs were created to serve the growing automotive sector. Through close cooperation with the OEMs and lead suppliers, the offerings of the various IFMIAs were continuously revised and expanded. Currently, three IFMIAs operate in the core automotive clusters in Morocco, praised without exception by all the interviewees as providing highly effective skill development programmes. In addition, in October 2021, the Competence Center on Automation (CCoA) was set up in Morocco with the support of the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) under the leadership of Steinbeis University in Germany. Several German companies from the electrical industry, such as Pflitsch GmbH, Phoenix Contact, Rittal and Siemens AG, are supporting the CCoA (Competence Centre on Automation, s.a.). The goal of the CCoA is to offer training on the vocational and academic level for the skills required for industrial automation and development, with a focus on the automotive, agriculture and food-processing sectors.

R&D capabilities have also been gradually increased, especially since Stellantis' large investments in Morocco. In 2017 Stellantis (the PSA Group at that time) signed an advanced research agreement with nine universities and schools (Ministry of Industry, s.a.-c). The OpenLab "Sustainable Mobility for Africa" also launched a research programme over four years. The programme explores sustainable mobility systems around three main axes: e-mobility, renewable energies and the logistics of the future (Ministry of Industry, s.a.-c). Stellantis has also joined forces in 2019 with the Technical Center of Vehicle Equipment Industries (CETIEV) for the development of R&D activities in the automotive sector in Morocco ("Automotive: PSA joins forces", 2019). As such on 9 April 2021, the Ministry of Industry inaugurated the new CETIEV 2.0, which will be carrying out "for the first time in Morocco physical tests related to automotive development and validation activities, more particularly electrical/electronic, mechatronic, acoustic and vibration testes as well as vehicle synthesis analyses" (Marklines, s.a.). Other such initiatives that contribute to building up Morocco's R&D capabilities in the automotive sector are emerging and the market has further developed. For instance, in 2019 Segula Technologies opened a centre of excellence for automotive engineering in Agadir, offering advanced technology solutions in the areas of electric and hybrid cars, driverless vehicles, AI, 3D printing and the digital transformation of factories, not only for Renault and Stellantis, but also for Daimler, Volkswagen and Ford (SEGULA Technologies, 2019).

52 Interview with FEV, March 2021.

5.2.2 Technological readiness

The close coordination between the Ministry of Industry, AMICA, AMDIE and the IFMIAs contributed to attracting key international players in the automotive industry and to the gradual upgrading along the supply chain. With Stellantis' investment in building a complete ecosystem and its commitment to increase local sourcing and produce engines locally, Morocco currently has a complete supply chain for the production of passenger cars. In addition, systematic investment in education and skill development, digitalisation and supplier development programmes have also enabled the emergence of Moroccan know-how in the manufacturing of parts and components as well as in engineering services, as we discuss below.

As part of PAI, the Ministry of Industry has set up six automotive ecosystems to attract Tier 1 suppliers and to build up Tier 2 and Tier 3 suppliers locally (Hahn & Vidican Auktor, 2017; Kanouni, 2020) (see Table 5).

Table 5: Automotive ecosystems to boost upgrading

Wiring ecosystem	Production of cables and copper wire components to improve vehicle connectivity and injection systems. Global operators active in wiring in Morocco: Yazaki, Delphi, Fujikura, Sumitomo, Lear, MTA, Leoni.
Metal and stamping ecosystem	Focusses on steel tooling, tubing and cataphoresis producers for the automotive industry. Global operators active in metal fabrication in Morocco: PSA, Renault, Snop, Gestamp, Socafix, GMD, Tuyauto.
Battery ecosystem	Aims at further developing lead recycling activities and improving the sourcing of other sector inputs to enhance stakeholder competitiveness. Battery operators active in Morocco include: Electra, Almabat, Tecna, Maribat.
Vehicle interior and seat ecosystem	Incorporates the production of car seats and vehicle interior components such as textiles, foam, blow moulding and glass. Global operators active in this ecosystem are: Faurecia, SIGIT, Polydesign Exco, Reydel and GMD.
Power-train and engine and transmission ecosystem	Covers cast iron casting, aluminium die casting, aluminium pressure injection, aluminium refining and engine machining. Global Mecaplast is the main player.
Truck and industrial vehicle body ecosystem	Relates to the manufacturing, assembly, transformation and fitting out of busses, trucks and industrial vehicles. The ecosystem seeks to foster the local integration of truck, industrial vehicle and automobile manufacturers. Principal operators include: Scania Morocco and Irizar.
Source: Author, based on Kanouni (2020)	

Two other ecosystems were created around the Valeo and Delphi OEMs to diversify suppliers and improve competitiveness. Given the large and complex investments that Stellantis has committed to in Morocco, the company plays a catalysing role for the entire sector in terms of not only guiding the government on needed interventions but also attracting new players to localise in Morocco.[53] The group anticipated that the local

53 Interview with FEV North Africa, March 2021.

purchase volume will exceed €1 billion by 2022, relying mostly on local suppliers and aiming for 80 per cent local integration of transnational suppliers – having already stated a 60 per cent rate of local integration (PSA plant in Morocco's Kenitra, 2018). To further increase the rate of local integration, AMICA currently seeks to further expand vehicle manufacturing as well as investments in power-train, R&D, air conditioning, vehicle architecture and tyres.

In terms of technological readiness in the automotive sector in Morocco, interviewees agreed that although Morocco may not yet be at the forefront of automation and digitalisation in manufacturing,[54] it will play a critical role in the next decade in terms of optimising conventional/mainstream technologies.[55] The argument provided by the interviewees is that OEMs are contemplating a potential shift in conventional automotive manufacturing (based on the internal combustion engine) from Europe to North Africa, while the automotive industry in Europe concentrates on electric vehicles. This would also follow a flying geese pattern of more technologically advanced manufacturing processes shifting away from CEE to Morocco as labour costs and labour shortages increase. As such, the upgrading of current production facilities will follow and opportunities for Moroccan Tier 2 and Tier 3 suppliers to enter GVCs will increase.

OEMs in Morocco use state-of-the-art technology and production processes while also relying on labour availability and lower labour costs. To stay competitive, however, firms along the supply chain have to invest in technologies and know-how to improve efficiency and productivity. The new CETIEV 2.0 and Stellantis' R&D centre are the most recent examples of investments in technology. Also, Renault Maroc launched a Digital Hub in 2020 to accelerate the digital transformation of its various activities in Morocco as well as in other regions (Guessous, 2020). One of the first projects of the Digital Hub has been a digital platform that anticipates quality issues, facilitates operator management and limits travel according to operating models (Guessous, 2020). Moreover, a Chinese-funded Tech City, Cité Mohammed VI Tanger Tech, is expected to include automotive, aeronautics and renewable technologies hubs that are focussed on technology and product development (Olayinka, 2019).

In light of global technological shifts and competitive pressures in the automotive sector, Morocco is increasingly seen as an extension of European (and Asian) OEMs. Specifically, Morocco's advantages in terms of labour surplus, lower labour costs, location and capabilities make it an attractive destination for shifting manufacturing and services related to conventional technologies around the internal combustion engine. Investments in technological upgrading would then be mostly aimed at optimising the manufacturing processes, while core automotive clusters in Europe focus on state-of-the-art technologies such as self-driving cars and electric vehicles, as mentioned above.[56] As labour costs increase, automation will follow. As such, industrial policy can still play an important role in further upgrading the capabilities of MSMEs to increasingly rely on R&D and more sophisticated technologies.

54 Unfortunately, no hard data was found on relative levels.

55 Interviews with FEV North Africa and SEW Eurodrive, March 2021.

56 Interviews with FEV North Africa, SEW Eurodrive, Altran, May 2021.

This is already the case, as differences exist in terms of the level of technological sophistication of production processes, between for instance the production plants of Renault Maroc in Tanger and Stellantis in Kenitra. Back in the early 2000s, Renault literally shifted an older production plant from France to Morocco that has been marginally upgraded over the years. Stellantis built a state-of-the-art digitally inter-connected facility in Kenitra in 2019, "getting close to the Industry 4.0 standards".[57] The level of technological and digital sophistication then depends on the volume of production that can be produced locally, the level of capabilities and the cost competitiveness achieved locally.

As mentioned above, Stellantis has become a catalyst for the sector, attracting players such as FEV Germany to set up a homologation testing, R&D and engineering centre in Morocco (the first one in Africa and the first of its kind outside of Europe).[58] As Stellantis is aiming to develop a complete vehicle in Morocco, it becomes increasingly important to be able to do tests on prototypes along the full life of the vehicle, including emissions and for different components such as the power-train, gear box and engine. Such local technological capabilities are also relevant for attracting other potential investors in the sector.[59]

There is an important opportunity for Morocco to expand its role in engineering services associated with manufacturing, nationally and internationally. Outsourcing of IT services has become a strong export sector for Morocco in the last decade.[60] These capabilities, combined with the accelerated growth in the automotive and aeronautic sectors and strong engineering education, have contributed to the emergence of know-how in high-end engineering services. As a result, companies such as Alten Maroc and Altran Maroc, which offer advanced product and process engineering and IT enterprise services, grew significantly in the last years and offer such expertise not only to firms in Morocco but increasingly abroad.[61] Altran Maroc has also expanded into offering specialised Industry 4.0 services for the automotive sector by managing the robots in production lines.[62] Altran Maroc is offering more than 95 per cent of its services to the automotive sector abroad, 70 per cent to French OEMs and 30 per cent to others, mostly European firms.[63]

The Covid-19 pandemic accelerated growth in this niche market. In particular, German OEMs have become increasingly interested in outsourcing such services to Morocco, given the lockdowns and transition to home office practices. Morocco has been adept at capturing this market for Porsche and BMW, for example, and been able to offer high value-added engineering services (such as safety and crash tests).[64] The market, however, is changing and the competition is getting tougher. Importantly, the tasks/services that are being imported by large OEMs are not purely about engineering anymore, but they have become more complex, shifting more risk to the supplier while requiring more value added (i.e. "not

57 Interview with SEW Eurodrive, March 2021.

58 Interview with FEV North Africa, March 2021.

59 Interview with FEV North Africa, March 2021.

60 Interview with APEBI, January 2020.

61 Interviews with Alten and Altran, January 2020, May and June 2021.

62 Interview with Altran Maroc, May 2021.

63 Interview with Altran Maroc, May 2021.

64 Interview with AHK, February 2021; Interview with Altran Maroc, May 2021.

only buying competency but results", Interview with Altran Maroc, May 2021). The labour–cost differential in Morocco, coupled with an increase in the complexity of engineering services offered, create opportunities for outsourcing these services from CEE (where the market is saturated and wages are much higher) across the Mediterranean.[65]

This requires service providers in Morocco to invest in competence centres, R&D and training. The joint venture in 2018 between Altran and Magna – a global technology supplier for the automotive sector – resulting in the Maroc Engineering Center (MG2), is one such initiative to build competencies for the growing automotive sector in Morocco and for exports. Another change observed in this market is an increase in consolidation driven by tougher competition, with firms such as Altran Maroc and Alten Maroc capturing more of the market, and smaller firms being pushed out of the market. Another indication of market consolidation driven by tougher competition is the acquisition of Altran by Capgemini,[66] which was finalised in early 2021 and combines the operational technology capabilities (engineering and R&D) of Altran with Capgemini's digital manufacturing expertise into Capgemini Engineering (Flaherty, 2021). As a result, Capgemini Engineering is positioning itself as an "intelligent industry" solution provider around "Engineering 4.0 and Industry 4.0 and expands in smart technology-driven segments such as IoT, AI, 5G, cloud, edge, data and cybersecurity" (Bakalova, 2019). Moreover, Prettl Automotive, a new player in the e-mobility market in Morocco, also aimed to set up an engineering and design hub for e-bikes while targeting the build-up of mid-management and engineering skills in the sector. All these initiatives, along with progress in digitalisation in the private sector, are expected to significantly contribute to further upgrading in the automotive sector.

Overall, the level of automation and digitalisation in the sector has increased significantly since a decade ago,[67] but it is certainly not at the cutting edge of technology. Asked to situate Morocco along a scale of technological advancement in the automotive sector, most interviewees agreed that firms are somewhere between Stages 3 and 4 (as described in Figure 2, with Stage 1 representing no Industry 4.0, and Stage 5 representing a completely automated factory), with some firms still in Stage 2, especially those that produce lower output volumes. Some have been more optimistic, claiming that some OEMs produce at the "Industry 3.0 or even 3.5 level".[68] Suffice it to say, however, that with a focus on building ecosystems around key OEMs and upgrading Tier 2 and 3 suppliers, the complexity of tasks delivered locally will increase. As the volume of production increases across ecosystems, the level of interest in improving efficiency through automation will also be higher among local suppliers. Efforts such as those of TE Connectivity are illustrative, as they are working

65 Interview with Altran Maroc, May 2021.

66 Capgemini is a global leader in consulting, technology services and digital transformation, working for the automotive, aerospace, aeronautics and systems engineering.

67 As an interviewee mentioned, 10 years ago Morocco was only producing harnesses for the automotive sector; now it is producing everything except the motor (Interview with TE Connectivity, June 2021).

68 Interviews with SEW Eurodrive, March 2021, and TE Connectivity, June 2021.

closely with a select number of suppliers to develop their capabilities by improving efficiency through automation so that they can then receive larger orders.[69]

As such, the vision for the automotive sector for the next decade seems to converge across the local stakeholders. Specifically, Morocco will most likely "pragmatically play mid-field, in the middle-high and middle-low market segment" when it comes to Industry 4.0 in the automotive sector.[70] That means it will capitalise both on the labour-cost advantage and its advanced engineering and technology skills to attract: (1) more investment along the value chain and around the automotive ecosystems, and (2) more opportunities for exporting complex engineering and technology services to Europe and North America.[71] In the short and medium terms, Morocco is seen as capturing a large market segment relocating from CEE. The automotive sector in Morocco can capitalise on its agility and flexibility, its increasing need for customisation[72] and its growing capabilities in industrial services by offering a competitive mix of manual and automated industrial processes.

To achieve this vision, skilling and reskilling are seen to be key. Given that the automotive sector still finds itself in the growth phase, the expectation is that increasing automation will not replace labour, but it will shift it to higher value-added tasks. The challenge, however, is to transform the jobs (i.e. the competences) from workers to operators of technology and systems. Furthermore, understanding what skills are needed and preparing the labour market are therefore crucial. The last years have seen important changes in this respect, with the government restructuring the training system and its focus, for instance by "dropping 80 specialisations and replacing them with new ones that are market driven" in close coordination with the private sector.[73] New initiatives in this regard are also emerging to close potential gaps in the market, such as StratField, a new joint venture with a German company that is focussed on advanced technological skill-building (which the company calls "speed upscaling") and outsourcing of Industry 4.0-related manufacturing services.[74] Overall, however, the scale of training programmes must also increase, as the competition for skilled labour is increasing in the automotive sector.

Aside from skilling and reskilling programmes, there is still scope for industrial policy to play an important role in further developing supplier capabilities by better integrating Tier 1 with Tier 2 and Tier 3 suppliers. Although Stellantis has followed a strategy of localising the entire value chain in Morocco from the beginning, many parts and components are still imported and assembled locally. Enabling Moroccan MSMEs to scale-up their production

69 TE Connectivity argues that a common problem for many companies that have located manufacturing in Morocco is the lack of large domestic suppliers able to take up bigger projects/orders. To address this challenge, TE Connectivity set up a sourcing committee that ultimately selected three local suppliers to work with systematically to build up their capabilities and improve operations, so that they can gradually scale-up their operations (Interview with TE Connectivity, June 2021).

70 Interview with Altran Maroc, May 2021.

71 Interviews with FEV, SEW Maroc, Altran Maroc and TE Connectivity.

72 "Cheap things will still go to China, highly customised will come to Morocco" (Interview with Altran Maroc, May 2021).

73 Interview with TE Connectivity, June 2021.

74 Interview with APEBI, June 2021.

capacity, increase quality and know-how,[75] and adapt more advanced manufacturing technologies that would increase productivity could contribute significantly to the sector's competitiveness.

5.3 Prospects and challenges in the garment sector

After decades of marginalisation in national development strategies, the textile, leather and garment sector has re-emerged on the agenda of policy-makers, especially in the last two years. After a large number of producers in Fes (the regional centre of textile and garment production) quit the sector for more lucrative investments, the sector has spun into decline since the 1990s.[76] Competition from China and Turkey has significantly squeezed profit rates for firms across the sector, with most companies acting as subcontractors for a limited number of European fashion firms. Moreover, a strong dependence on the import of raw materials has, over the years, limited the competitiveness of Moroccan producers and suppliers.

Yet, the Covid-19 crisis has turned policy-makers' attention back to the textile and garment sector, both because of the sudden economic shock and risk of unemployment for a large share of socially vulnerable workers, as well as because of the demonstration of agility that the sector has displayed. Specifically, in the face of a sudden large global demand for surgical masks, Moroccan producers were able to quickly switch their production lines and delivered 300 million masks by June 2020, becoming the second-largest global producer after China.[77] Working in close coordination with the national standards and certification agency, national producers were also able to manufacture equipment for mask production and respirators.[78]

As a result, in addition to the impacts due to the sudden economic shock created by the Covid-19 pandemic on the textile and garment sector dominated by MSMEs, the Moroccan Association for the Textile and Garment Industry (AMITH) articulated a new vision for the sector at the end of 2021 called Dayem Morocco. Dayem Morocco encompasses a national strategy to develop the textile and garment sector by 2035 into a globally competitive and environmentally sustainable industry that is also able to create jobs. Four main aspects are part of the vision: (1) strengthening the sector's ability to adapt to the needs of its customers, (2) boosting innovation, (3) integrating sustainability in production practices and (4) consolidating the offer along the entire supply chain (Belouas, 2021). Advancing digitalisation in production planning, manufacturing and quality control is viewed to be critical both for improving competitiveness as well as for better positioning local producers to reduce their time-to-market, improve quality and better respond to customers' demands.

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75 Till Hesse from the International Center for Logistics in Germany mentioned that product specifications are hard to find for automotive products and processes (e.g. for coating). Many local companies could become suppliers for Tier 1 but need the product specifications (i.e. know-how). Attracting more foreign investors (i.e. German in particular) and developing partnerships with local firms could contribute to such knowledge transfer for upgrading (speech at AHK Business Talk: Automotive webinar, 23 September 2021).

76 Interview with Mohamed Behnassi, February 2021.

77 Interview with the Ministry of Industry, January 2022.

78 Interview with the Ministry of Industry, January 2022.

The renewed interest in the sector is justified by the strategic importance it has for Morocco from an economic and social point of view. In 2018 it accounted for 30 per cent of manufacturing employment, 8 per cent of manufacturing value added and 7 per cent of manufacturing output (UNIDO, s.a.). The entire sector includes about 1,200 companies,[79] 80 per cent of which work in sewing,[80] employing 185,934 people in 2018 (UNIDO, s.a.), including major players such as the Spanish firm Inditex, which combines the Zara and Bershka brands, for example. Moreover, 56 per cent of all women employed in manufacturing work in the textile, garment and leather sector (UNIDO, s.a.). Informality is also very high, with 44 per cent of all informal units[81] being concentrated in this sector in 2014, employing 7.4 per cent of informal workers and producing 28 per cent of informal output (Haut-Commissariat au Plan, 2014).[82] Therefore, it is important to stress the extreme heterogeneity present in this sector: Large export-oriented sewing plants coexist with small and often informal businesses producing for the local market. Indeed, more than 93 per cent of all textile and garment exports are destined for the European market, especially Spain and France.[83] PAI also placed a strategic focus on the textile, garment and leather sector while aiming to create 20 per cent of the targeted 500,000 total new jobs it planned to achieve in this industry by 2020.

Within the sector, the largest share of employment, output and value added are concentrated in the garment sub-sector. Therefore, we focus next mostly on this sub-sector, as this is also the segment that is least technologically advanced but where most innovation and technological advancements are expected to increase productivity and boost exports, as discussed in Section 4. We discuss below how policy-makers envision and support developments in this sector, what policy instruments they use for this purpose and who the main stakeholders are. Once these framework conditions are explained, we turn our attention to the current level of automation and digitalisation as well as to the challenges and opportunities for technological upgrading in the future.

5.3.1 Policy framework and key stakeholders

The main national strategy document that highlights the vision for the entire textile, garment and leather sector is the Plan Textile 2025, published in 2014. The strategy focusses on accelerating growth, creating 250,000 jobs and exporting 85 billion dirhams worth of goods ($9.87 billion) (up from 38 billion dirhams in 2018). To achieve these goals, attracting large job-creating investments is key. The Plan Textile 2025 has been rolled out in two stages: a start-up stage during 2020, followed by an acceleration stage over the following five years (Oxford Business Group, 2015). A key focus of the start-up stage was dealing with core

79 The website of the Ministry of Industry shows 1,075 companies in this sector. The difference may come from the leather processing companies, which are treated separately.

80 Interview with ESITH, February 2021.

81 The informal units produce for the local market and are most of the time outside the scope of policy interventions, which may aggravate their social and economic situation (Interview with the Denim and Fashion Cluster, February 2021).

82 The most recent year in which a survey of the informal sector was done in Morocco is 2014.

83 In 2018 Morocco's textile and clothing sector's exports represented 18.5 per cent of the EU's total imports from the country (Volkmann, 2020).

challenges that constrained development across the sector. One such constraint was the limited in-country access to raw materials, which led to low levels of competitiveness of the increasing number of firms operating in the fast-fashion segment (Oxford Business Group, 2015; Volkmann, 2020). The second stage, from 2021 onwards, targets market growth, production, quality, employment and export sales (Volkmann, 2020). It is unclear to what extent the sector's development strategy focusses on the myriad of small informal firms with limited technological capabilities that dominate the sector. Therefore, most of our analysis in this paper is centred on those firms that already engage in export markets, or could do so with adequate policy support.

The Covid-19 pandemic has significantly affected the sector.[84] This is due to disruptions both in supply chains and export demand[85] as well as in communication patterns with clients, revealing a widespread lack of basic digital infrastructure for most MSMEs, except for the few export-oriented firms, as we discuss later. The change in global sourcing has also led these more dynamic Moroccan firms and their clients (large European garment firms) to explore regional (closer to home) opportunities for sourcing. In this context, new opportunities have emerged for Moroccan firms, mostly due to the location advantages of being close to Europe and in the middle of supply routes between North America and Asia, as many foreign contractors are also turning to local suppliers (Textile Value Chain, 2021; Interview with AMITH, February 2021).

Within this context, in order to strengthen the sector's resilience to future shocks and reposition the Moroccan firms on the export markets, AMITH aims to localise the entire ecosystem for garment production, from conceptualisation to yarn and fabric production, garment manufacturing and all the way to customer delivery (see Figure 3 in Section 4). This calls for entirely new ways of organising the supply chain, adapting to new business models and investing in skilling and reskilling. As AMITH recognises, in order to operationalise such a sectoral development strategy, real-time information is essential and calls for rapid digitalisation and automation across the production process, requiring "a new logic of production as producers have to be reactive to market needs" (AMITH, s.a.).

Specifically, the Dayem Morocco strategy articulates the following goals (Benabdellah, 2021). First, it aims to create 50,000 new jobs by 2025. To this end, a range of training and R&D programmes are envisioned to strengthen capabilities related to design, digitalisation and Industry 4.0, sustainability and marketing. Second, it seeks to develop so-called eco-parks around Casablanca and Tanger, which would also integrate innovative platforms for start-ups in the sector. Third, the strategy aims to achieve a 40 per cent share of local content and create 10 national brands by 2025. Fourth, Dayem Morocco also seeks to integrate the informal sector, which currently represents almost 180,000 workers. Investments in digitalisation, especially related to enterprise resource planning (ERP), and in quality improvements are equally targeted by the new strategy.

84 The Covid-19 crisis led to the shutdown of 90 per cent of the sector in March and April 2020, endangering thousands of workers and families. Many companies in the sector quickly reoriented their production to produce masks to meet national and international needs ("Morocco's textile and clothing sector", 2020).

85 Estimates show that from 2019 to the end of April 2021, the EU's garment imports from Morocco declined by 22.1 per cent (AMITH, s.a.). As a result of such disruptions and market volatility, 80 per cent of companies froze all investments for 2021 (Belouas, 2021).

Except for a few large players in the sector, this vision for how the sector should operate and the necessary tools to make it happen are novel. Until now, the Moroccan garment sector has been driven by a low-cost labour force, proximity to Europe, limitations in supply,[86] high competition from Asian markets and a strong reliance on a few large European clients. Over the years, this has meant stagnation, limited competitiveness, and a reliance on more conventional and traditional modes of production. With new opportunities on the horizon created by recent global supply shocks (i.e. increased relevance for time-to-market, the shortening of GVCs and the regionalisation of supply chains), policy-makers and lead firms in the sector stand ready to engender a new impetus for growth and competitiveness.

The needed transformations are, however, not easy to initiate. First, the sector is structured into a few large garment producers supplying European clients, a large number of MSMEs with limited capabilities and ability to invest in technological upgrading, and a sizeable informal sector relying on low-cost labour. Until recently, the garment sector was almost entirely specialised on CMT (cut, make and trim), targeting the European short-ordering segment. However, increasingly, the industry association, AMITH, is seeking to improve the capabilities of firms to provide full collections, thus becoming "more attractive to brands and retailers and able to better manage their stocks" (Volkmann, 2020).[87]

PAI, with its focus on supporting the development of ecosystems, has structured sector-level interventions in six key clusters/ecosystems: denim, fast fashion, knitwear (mesh), home textiles, textiles for technical applications and industrial distributors of national brands (Ministry of Industry, s.a.-b). Under PAI, government support for these ecosystems has been generous (as seen also in the case of the automotive sector in Section 5.2), ranging from typical investment and export promotion incentives (see Table 6[88]) to the MarocPME programmes for the upgrading of MSMEs, as discussed in Section 5.1. In addition to these support measures, MarocPME also supports firms with feasibility studies for digitalisation and with supporting investment in automation. Few companies, however, have made use of these incentives so far.[89]

86 Especially constrained by the need to source raw materials (e.g. fibre) and accessories from Asia.

87 A similar argument has been provided in interviews with AMITH and DEPF.

88 These incentives reflect the ones considered under Dayem Morocco since, at the time of publication, the specific measures had not yet been clearly articulated.

89 Interview with the Denim and Fashion Cluster, February 2021.

Table 6: Government assistance and support for firms in the textile, leather and garment sector	
Area of intervention	**Instruments**
Tailored financial support	o Innovative bank financing solutions for textile operators based on an agreement signed between AMITH and Bank Populaire.
Investment promotion	o 95 hectares of rental property reserved for the sector. o Investment Promotion Fund covers up to 20 per cent of the cost of the land, up to 5 per cent of the total amount of capital investment or 10 per cent in the case of an investment in the sector of spinning, weaving and finishing. o One-stop service for investors.
Export promotion	o Exemption of import duties on capital equipment, materials and tools necessary for the implementation of an investment project with a total cost greater than 200 million dirhams during 36 months after the signing of the investment agreement. o Simplified customs procedures. o Exemption from VAT on imports of capital equipment, materials and tools necessary for the implementation of an investment project with a total cost greater than 200 million dirhams until 36 months after the start of activity. o Unlimited exemption from VAT in respect to products delivered and services supplied to the free export zones.
Tax incentives	o Exemption from income tax during the first five years, and then a reduction of 80 per cent of tax on gross earned income during the following 20 years. o Exemption from corporate tax for the first five years, and then a rate of 8.75 per cent for the following 20 years. o Exemption from professional tax for the first 15 years. o Exemption from urban tax for the first 15 years. o Exemption from participation in national solidarity. o Exemption from tax on income from corporate rights, dividends and similar income for non-residents and a reduction in tax to 7.5 per cent for residents. o Exemption from registration fees and stamp duty on instruments of incorporation or increases in the capital of the company, as well as on land acquisitions.
Training	o Training programmes tailored to the needs of the sector, in partnership with training institutions, including OFPPT. o The Investment Promotion Fund covers up to 20 per cent of the cost of training.
Source: Author, based on information from the Ministry of Industry (s.a.-b)	

AMITH plays a critical role not only in ensuring that the national sector development strategy is being implemented within the selected ecosystems and by the firms and other stakeholders. It also acts as an ecosystem catalyst identifying synergies and fostering collaborations across stakeholders in the private and public sectors. This new post-Covid sector-level dynamic has brought, however, new challenges for AMITH. The impetus for transformation and change conveyed by the Ministry of Industry in 2020 has called for AMITH to rethink their offer of support for firms, and it created opportunities for enabling firms to technologically upgrade their operations and rethink their business models.[90]

90 Interviews with AMITH and Vita Couture, February 2021.

Through its close engagement with firms and the observation of market trends, AMITH is making an effort to set the long-term vision for the sector and lobby for the interests of the firms. As such, more recently, AMITH has developed a roadmap for the sector that is focussed on four main pillars: adapting more to the needs of customers, boosting innovation, integrating sustainability in firms' operations and technological upgrading (Textile Value Chain, 2021; Interview with AMITH, February 2021).

The Ministry of Industry has also been supporting the set-up of sectoral clusters[91] since 2014: the Moroccan Cluster for Technical Textiles (C2TM), the Moroccan Denim and Fashion Cluster (MDFC) and a cluster for home textiles, which has not yet started its activities. In light of the sector being dominated by traditional production practices and the fast pace of technological developments worldwide, both clusters play the role of improving the awareness of their member companies with regards to new technological trends.

The C2TM aims to increase the value added of Morocco's technical textiles producers. Companies in this market segment target clients in the automotive sector, agro-textiles, occupational clothing, home textiles and geotextiles. The C2TM cluster supports its 35 member companies with detailed information on existing national and international suppliers and sourcing of raw materials, the promotion of companies in domestic and international markets, support with the adoption of standards and national regulations, as well as training and awareness programmes.

The MDFC[92] focusses on three core aspects: integrating sustainability into the Moroccan product offers, technological upgrading of production tools, and process and design innovation. Currently, 45 companies are members of the cluster – all manufacturing firms – interested in innovation, active in capacity-building and working with start-ups or younger firms as well.

Higher-level education and research for this sector is channelled through the Higher Education Institute for Textiles and Clothing (ESITH). The university is also at the core of the sectoral clusters, working closely with firms and the industry associations to align their curriculum offerings to the evolving needs of the sector. ESITH also serves as a centre for the research and testing of new technologies, demonstrating to firms how more advanced technologies could contribute to problem-solving and increase in productivity. Along with ESITH, Casa Moda is another university focussed on the design and fashion market segment.

Another important actor is the Technical Center for Textile and Clothing (CTTH), which focusses on conformity assessment, technical assistance and process optimisation. Lastly, AMDIE also plays an important role through its department for textiles and garment in linking domestic firms with international investors. This close cooperation between AMDIE, the Ministry of Industry and AMITH is also seen to be increasingly important for developing the concept of Made in Morocco in the textile and garment sector.

91 Overall, 13 industry clusters have been set up since 2013 in Morocco, across sectors, following the PAI aimed at deepening industrial upgrading.

92 Interview with the Denim and Fashion Cluster, February 2021.

5.3.2 Technological readiness

The garment sector is composed of a limited number of companies that are direct exporters and a majority of firms acting as subcontractors with little value added. Few companies are innovators with good market visibility and work directly with customers. Sluggish market dynamics in the past decades gave way to a large number of firms with a limited vision for the future that followed pragmatic investments with short-term returns based on traditional production practices.[93] This became a major constraint when it came to technological upgrading, capital investment and the ability to align the firm's strategy to medium- and long-term market trends.[94]

As such, the sector is highly vulnerable to changes on the regional and global markets, and its business model has remained labour-driven. In turn, most firms lack a long-term vision, have no drive to make greater capital investments and see the automation and digitalisation of industrial processes as being too far into the future.[95] The two clusters and the industry association, AMITH, have converged on these perceived challenges.[96] A slightly different perspective has been presented by C2TM – the cluster for technical textiles – which argues that, in this segment, the interest in new technologies is perceived to be higher primarily due to the solution-oriented products that firms in this segment offer across dynamic sectors such as automotive and aeronautics.

As such, the technological readiness of firms across the garment sector remains generally low, and it appears to be especially driven by (mainly European) customers' demands. Few companies are willing to adopt technologies that set themselves apart from the competition, even with government support. Among the reasons mentioned are high investment costs and a lack of awareness with respect to the benefits associated with technological upgrading in light of low labour costs. Consensus exists, however, that a balance has to be reached between Morocco's comparative advances in low-cost manufacturing and the vast opportunities that advanced technologies can offer for productivity and quality improvements.

Overall, however, few companies have adopted technologies and digital systems that are standard or best practice today. Currently, such technology adopters are isolated cases within the various market segments.

Starting from a very basic level, while most firms may have a website and use the Internet, a large majority do not view and use the platform as an interface between the firm and the marketplace. As a result, few companies are actively engaged in e-commerce. Yet, the halt in deliveries caused by Covid-19 was a wake-up call for firms to change their business models and upgrade. Therefore, AMITH launched a programme in 2020 to financially and technically support firms with upgrading their websites and teaching them how to use the platform to communicate the capabilities of the firm (and their offers) to potential

93 Interview with Mohamed Behnassi, February 2021.

94 Interviews with the Denim and Fashion Cluster and with Mohamed Behnassi, February 2021.

95 Interview with the Denim and Fashion Cluster, February 2021.

96 Interviews with AMITH, Denim and Fashion Cluster, and C2TM.

customers. AMITH, with the support of the GTEX/MENATEX[97] programme, is currently working with a few communication and marketing agencies to develop attractive and functional websites for the MSMEs in the sector.[98]

Digital solutions for production and process planning are currently hardly used by firms in Morocco. Only a few companies even have ERP systems to follow production, and "90-95% of companies do not even understand what ERP is and its benefits".[99] Moreover, even large firms with 10 production lines manually record production-related data.[100] Nevertheless, firms generally show interest in solutions that allow them to improve productivity and quality as well as to reduce delivery times and costs.[101] However, the investment cost remains an issue for the majority of companies with lower financial capacities, especially in conditions of market vulnerability. In addition, the lack of skills to operate such systems plays a role.[102]

Interest in more advanced integrated digital solutions began, especially in 2019, when an Italian provider, PA-Maghreb, set up a local presence in Morocco,[103] although other providers (primarily from India and China) were also exploring the Moroccan market.[104] AMITH and the two clusters have mobilised interest within the sector, organising workshops to present PA-Maghreb's solutions and the benefits they offer in terms of productivity improvements. MarocPME also offers to cover 70 per cent of the investment in such digital solutions (up to 400,000 dirhams). Until now, only one company in the garment sector had adopted two of the modules offered by PA-Maghreb, specifically digital solutions for monitoring and quality control.[105] It is expected, however, that demand for such solutions will increase in the future. As we discuss later, awareness of the benefits associated with such technological investments remains limited.

In terms of advanced design solutions, just a couple of large companies appear to be using digital design solutions such as CAD for sampling, printing and design. One company in particular, based in Tanger, is using 3D design solutions, following a joint venture with a Spanish company.[106] The necessary skills, however, are missing, and there is a call for training and education institutes to develop the know-how in this area.

97 The GTEX/MENATEX programme is a three-year programme implemented by the ITC within the framework of the Global Textiles and Clothing Program (GTEX-Egypt, Morocco, Tunisia, Kyrgyzstan and Tajikistan) and by the Swedish government within the context of the Middle East and North Africa region Program Textiles (MENATEX-Egypt, Jordan, Morocco and Tunisia) with co-financing from the government in the case of Morocco ("Morocco's textile and clothing sector", 2020).

98 Interview with AMITH, February 2021, and with ITC, May 2021.

99 Interview with Vita Couture, February 2021.

100 Interview with Vita Couture, February 2021.

101 Interviews with ESITH and Mohamed Behnassi, February 2021.

102 Interview with Vita Couture, February 2021.

103 There are currently no digital solutions developers in Morocco. Several resellers of software are present from France, Italy, Portugal and India, and most are not cutting edge (Interview with Vita Couture, February 2021).

104 Interview with PA Maghreb, March 2021.

105 Another company showed interest but finalisation of the contract has been delayed due to the Covid-19 crisis (Interview with PA Maghreb, March 2021).

106 Interview with Vita Couture, February 2021.

Furthermore, for denim, for example, not all technologies that are considered standard in the sector, such as CNC cutter tables and abrasion robots, have been adopted in Morocco. A few firms have invested in automated CNC cutting machines because they understood that these are faster and therefore reduce both the delivery time and labour costs. But instead of abrasion robots for denim, some companies are using lasers, which is a more mature and cheaper technology.

Few companies have adopted technologies that are considered best practice today in the industry. Sewing, which is the most labour-intensive production process, is largely based on manual labour, except for the one firm testing pocket-sewing robots for denim. Although this technology has only been recently adopted, the company has already reported cost reductions.[107] Given the low labour costs in Morocco and the weak drive to invest, expectations about automation in this segment in the short and medium term remain low.

A couple of companies use laser systems for printing due to a partnership with an Italian firm.[108] Moreover, no automated loaders for drying are used, or hanging conveyor dryers. But the washing sub-segment has been more dynamic recently when it comes to technological upgrading. In particular, one company using chemical washing substances automated the process after the customer requested a better environmental performance, leading also to cost reductions.[109] As a result, more companies became interested in investing into new technologies driven also by more stringent environmental regulations.

Especially due to cost considerations, quality inspections are still performed manually, in spite of efficiency losses. Perhaps just a couple of companies use fabric vision systems.[110] Labour costs are too low to shift to digital tools such as fabric vision systems, which are currently best practice in the industry.

When it comes to tracking and tracing along the production process, the barcode is the technology solution used across firms in Morocco. RFID (radio frequency identification) is still a new technology and only used by customers (e.g. Zara) in the last step of the production process to follow their stock.[111] An upgrade from barcode to RFID would only be done when the customers ask for it, in spite of the significant time-to-market improvements resulting from much faster inventory management.[112] The cost investment for shifting to RFID can be significant, as this technology can be 10 times more expensive than barcode readers, and implementation can be difficult and time-consuming (PEAK

107 Interview with AMITH, February 2021.

108 Interview with AMITH and Montepull, February and April 2021.

109 Interview with the Denim and Fashion Cluster and Mohamed Behnassi, February 2021.

110 In the interview with AMITH (February 2021), it was not clear whether this technology has been adopted by Moroccan firms.

111 Interview with ESITH and AMITH, February 2021.

112 As barcodes require manual reading, the use of this technology is much more prone to human error. RFID, on the other hand, can guarantee more consistent results. Another important difference is that "while barcode scanners require a line of sight to scan each code individually, RFID scanners can read multiple codes at once" (see http://www.peakteach.com). The use of RFID also facilitates the automation of inventory management and can store more information than the barcode. RFID-powered systems also allow for a better leverage of data and for automation, not only in inventory management but also across the sales cycle (see http://www.nordicid.com)

Technologies, 2019). Yet, some companies are experimenting with RFID – Decathlon being one such example – to manage the flow of goods.[113]

That the garment sector in Morocco has adopted by now only some of the most standard automation technologies shows not only a major gap in digitalisation; it also shows the major potential for automation and technological upgrading in the years to come, especially if nearshoring is expected to increase, triggered by supply disruptions during the Covid-19 crisis. To enable upgrading for cost reduction, productivity improvement and a reduction in the time-to-market, the two cluster organisations and AMITH have mobilised significant resources in the last year to provide market and technology insights, workshops and webinars. Until recently, however, few companies displayed interest in such informational materials.[114] To boost interest in the sector and animate key players in the private sector, the Ministry of Industry and AMITH organised a meeting with the textile and apparel sector in June 2021 to reflect on progress and set a new vision for the sector regarding upgrading along the supply chain, digitalisation and more active participation on export markets.

The training of technicians has also been repeatedly mentioned to be critical for enabling firms to upgrade. The already close collaboration between AMITH, universities and training institutions lays the foundation for enhancing skills. A better understanding may be necessary, however, about what types of skills and what level is required, given the expected market developments over the next decade. E-commerce, for example, does not seem to be of interest to MSMEs but rather for large companies and start-ups interested in working with a different business model. The MDFC cluster offers courses on sustainability, recycling, carbon prices and social conformity, but not on e-commerce. ESITH is also currently not highly engaged with developing a curriculum on e-commerce. AMITH is only now in the process of developing – together with ESITH and Casa Moda – a master's programme in digital marketing.[115]

Moreover, the GTEX/MENATEX programme, financed by the Swiss government and implemented by the International Trade Center (ITC), is also working with 36 companies in the sector to enable upgrading and facilitate export opportunities.[116] For example, a new online platform has been created, called AMITH Marketplace, to improve firms' access to information and connect buyers from the local and international markets with Moroccan suppliers. In order to enable companies to engage with digital technologies to facilitate market access and develop "a new way to think fashion" (Interview with AMITH, February 2021), AMITH is also in the process of developing platforms for digital showrooms to diversify the client base and target customers in the Nordic countries and the US market, for example.

113 Interview with ESITH, February 2021.

114 C2TM, for example, regularly publishes a newsletter for its members also with information on new technologies and innovations in the sector. Few companies, however, show interest in such reports (Interview with C2TM, February 2021). This is the reason why alternative information events are being considered.

115 Interview with AMITH, February 2021.

116 Interview with ITC, May 2021.

6 Conclusions and policy recommendations

Morocco's industrial development strategy of the last decade has resulted in several success stories and set the basis for further economic expansion. Growing an almost non-existing automotive sector into a regional hub by following a systematic approach for attracting investment, offering generous incentives and building capabilities has allowed Morocco to become an increasingly appealing destination for OEMs' nearshoring strategies and expand into the African continent. Although the automotive sector played an important role in job creation, its success as a technology-intensive sector will not significantly contribute to addressing the large unemployment problem in Morocco. Therefore, it became increasingly apparent that the garment sector – a sector with a long tradition in Morocco that currently employs a quarter of the labour force – needs to be brought back into the focus of policy-makers. The strategic importance of the sector also became evident with the Covid-19 crisis. During this time, European producers faced supply shortages and turned to Morocco due to proximity issues, and lockdowns in Morocco suddenly increased the risk of a social crisis, as thousands of families feared for their welfare.

Morocco's success with earlier industrial development strategies placed the automotive sector, in particular, on the global automotive industry map and laid out a vision to advance digital transformation in the economy. These early developments and long-term plans set the foundations for a development pathway aimed at playing a much larger role in GVCs and increasing private-sector competitiveness. The much-awaited NDM was therefore expected to offer a new paradigm for development that would position Morocco as a global and regional player. Yet, such a vision that builds on Morocco's comparative advantage and the new demands of the 21st century to engage with the fast-paced process of technological developments in manufacturing needs to further mature in the industrial development strategy.

Current developments and medium-term progress appear to be the result of industrial dynamics driven by regional and global market transformations and self-propelled developments resulting from earlier investments. The future of manufacturing in Morocco and its ability to capitalise on opportunities related to Industry 4.0 will therefore critically depend on policy-makers' capacity to develop a long-term and differentiated vision across sectors. In the new context, defined by new opportunities created by pressures to reorganise GVCs, industrial policy needs to equally engage the high-tech and labour-rich sectors with the new demands being imposed by technological advancements and changing market conditions, as discussed in Sections 2 and 3. The most recent strategic initiatives, such as Dayem Morocco for the textile and garment sector, clearly illustrate policy-makers' search for a new vision to build the capabilities necessary to become competitive on global markets. In addition, in early 2022, a cross-ministerial and cross-stakeholder initiative has been revealed called MoroccoTech, an ecosystem-based vision that aims to consolidate investments and strategic interventions to achieve technological upgrading across sectors and build the necessary capabilities (MoroccoTech, n.d.).[117]

117 As the initiative is still quite new, not a lot of clarity exists yet about what specific support measures and strategic interventions are envisioned. This should, however, become more evident over the course of 2022.

Our analysis clearly shows that interventions must be tailored to the different degrees of technological readiness. The automotive sector is driven more by the needs of major OEMs. Therefore, industrial policy should focus on setting the framework conditions, enabling upgrading by investing in R&D and shifting incentives towards facilitating local suppliers to better integrate with Tier 1 and Tier 2 suppliers. In the garment sector, policy interventions need to be more comprehensive, from developing a long-term vision to building awareness on technological upgrading and new business models enabled by digitalisation and automation. Moreover, there is extensive scope for industrial policy to contribute to building basic technological and knowledge capabilities all along the garment supply chain and to attracting investment.

Automation and digitalisation offer new and different opportunities across these two sectors. In the automotive sector, Morocco seems positioned to capture a large market driven by nearshoring opportunities (as discussed in Section 5.2) as a result of the shift (or expansion) of the periphery networks from CEE to North Africa. This will bring with it greater valued added and more technology-intensive manufacturing and services. Moreover, the servicification of manufacturing opens up opportunities for Morocco to increasingly play a role as an exporter of high-end engineering solutions to Europe and beyond. Lastly, while it is clear that Morocco will not be at the forefront of Industry 4.0 even in the automotive sector, increasing sector maturity and consolidation along the supply chain suggests that Morocco will "play in the mid-field" when it comes to automation and digitalisation, building on its growing know-how complexity and proximity to European markets.

The garment sector, on the other hand, sees extreme differences as compared to the automotive sector. Here, the challenge is one of both focussing on the basics when it comes to digitalisation (i.e. laying the foundations) as well as on understanding the changing context and being able to develop a vision for the sector. These aspects are becoming critical starting points for policy-makers as they identify core capabilities and areas of intervention to support firms in making the necessary leap forward that would allow them to capture the market opportunities that are emerging with the reorganisation of GVCs and new technological advancements in e-commerce and digitalisation in production.

Given these large differences, below we reflect separately on the two sectors with respect to the types of interventions Moroccan policy-makers should consider to improve competitiveness.

6.1 Automotive sector

The automotive sector has seen dynamic growth in the last decade, from limited production of some parts and components and car assembly, to an attractive location in Morocco for global OEMs and suppliers producing along the entire supply chain. The factors that led to this outcome are not only Morocco's lower labour costs, relative to Europe. Proximity to European and African markets, political stability, a well-developed and integrated transport infrastructure, and a solid training and education system were critical pull factors for investors. Moreover, capitalising on these factors was made possible by a systematic, visionary but pragmatic industrial development strategy, which has attracted key players such as Renault and Stellantis (among others) along with their ecosystem of international suppliers to set up production lines in Morocco. They were followed by other OEMs and a

multitude of suppliers, resulting in two major automotive clusters (in Tanger and Kenitra) and growing competition, serving both the European and African markets. The government's approach has combined generous incentives, investment promotion measures, a responsive approach to address the training needs of firms, regulatory stability and a focus on industrial upgrading along the supply chain by identifying growing and lagging ecosystems that needed additional interventions to attract investments and build capabilities (for more details, see Hahn & Vidican Auktor, 2017, 2018).

The Industry 4.0 global industry trends pose new challenges for the automotive sector in Morocco and open new opportunities at the same time. The new regional and global market conditions also call for an update in industrial policy. First, the fast pace of technological developments, increased competition and pressures for cost-cutting place additional demands on an already strained and resource-constrained government. Second, the type of industrial restructuring currently seen in the automotive industrial centres in Europe (due to higher costs and a shift towards "less manufacturing" and "more technology development") point to the clear potential that Morocco has to attract higher value-added manufacturing and move up to a "mid-field" market segment. As discussed in Section 5.2, another major opportunity for Morocco is that it can play an increasingly significant role in the export of advanced engineering services to lead firms in Europe and abroad.

To this end, several interventions may be considered to further support these developments in the coming years.

6.1.1 Assessment of local Industry 4.0 capabilities

The range of technologies and systems associated with Industry 4.0 are still new, not only for Moroccan firms and policy-makers. Yet, the speed of technology development is increasing, and the market dynamics around such technologies have intensified, also due to the Covid-19 crisis. Therefore, gaining a deeper understanding of local capabilities around the range of Industry 4.0 technologies is key in order to guide government-driven digitalisation efforts, better target efforts for industrial upgrading and support foreign investors to find suitable local partners/suppliers. APEBI has already initiated such an assessment effort within the ICT sector that developed a successful IT outsourcing cluster. But a more extensive and systematic data collection effort across sectors could be coordinated, especially given the cross-sectoral, cross-cutting nature of digital and automation technologies and systems.

6.1.2 Targeted investment promotion

At this stage in the development of the automotive sector in Morocco, it is the OEMs that are in the driver's seat for further expansion, locating key suppliers in their proximity as they broaden operations. Nevertheless, several interviewees stressed the importance of diversifying into other markets, for instance attracting more investors from Germany and North America. To this end, AMDIE could play an additional coordinating role between the OEMs and the industry association, AMICA, to attract additional investments that would not only diversify markets but also consolidate specific ecosystems and facilitate upgrading.

6.1.3 Further support skill development programmes

The skill development programmes in the automotive sector have already served as positive examples for other sectors in Morocco. The targeted and coordinated approach of government training centres – the IFMIAs – that follow the needs of the market has been commended by all stakeholders, both national and international. Yet, as the local industry becomes more complex and as the local firms move into higher value-added market segments and face more competition, the skill development programmes need to be one step ahead. Therefore, to reverse the growing level of scarcity of skilled labour in the sector, the capacity of the training programmes should be increased. Finding trainers with industrial experience is also a challenge, especially when the sector is currently in an expansion stage. "Train the trainer" programmes could, therefore, be further augmented. In addition, identifying gaps in the market and customising programmes to satisfy those needs is important. An example is the need for experts in mechatronics and for technicians.

6.1.4 Focus on supplier development programmes

Given the level of dynamism achieved in the automotive sector in the last years, there is an opportunity for the government, through MarocPME, to target much more the specific needs of MSMEs that must develop their capabilities, be it in terms of access to finance, or more importantly in terms of improving quality and training.

6.1.5 Invest in R&D capabilities

The last few years have seen important industry-driven investments in the R&D space, as discussed in Section 5. However, public investments in building an innovation ecosystem for advanced manufacturing technologies, product design and digital systems are only now emerging. An example in this regard is the recently founded CCoA, which is focussed more on engineering skills for the automotive and other sectors. Yet, investing in the development of R&D capabilities and increasing their complexity would be necessary for Morocco to be able to capture the opportunities created by the nearshoring of manufacturing from the CEE region and to be able to play a more active role in the servicification of manufacturing in the automotive sector. Such capabilities could easily be transferred across sectors, contribute to improving competitiveness and increase the knowledge intensity in total value added. Ultimately, it would add to Morocco's chances of becoming a hub for advanced technology services.

6.2 Garment sector

The renewed focus on the textile and garment sector following the Covid-19 pandemic created new opportunities for upgrading and repositioning Moroccan firms on export markets. Reinforced by the government's push for digitalisation across the economy, key stakeholders in the sector are mobilising efforts and expertise to explore how new process and manufacturing technologies can shift a highly traditional sector towards higher value-added manufacturing and higher productivity levels while diversifying export markets. As most interviewees agree, the key barrier to increased technology adoption is not the

availability of capital, especially now when the government is offering generous support packages. Instead, it is a lack of dynamism that defines the sector, with firms having for a long time depended on a few large customers with stable profit margins,[118] while more recently having to face high market volatility. In addition, most firms are not aware of the benefits associated with investments in new digital and automation technologies and cannot find the needed skills (especially at the technician level) to operate such tools.

Yet, in spite of the shocks for production and supply, the Covid-19 crisis has actually allowed companies to re-imagine their role in this sector in the economy in the near future. The current dynamics are pushing many countries in Europe to deal with nearby markets, which creates an opportunity for upgrading in this sector (Interview with Mohamed Behnassi, February 2021). Moreover, in light of the general trend observed globally, where reducing the time-to-market becomes ever more important along with product customisation, many companies in Morocco are also increasingly interested in working less as contractors and instead shifting towards offering full support packages.[119] Firms in Europe have also been increasingly shifting towards specialising in branding, design and buying the finished product from lower-cost countries. The North African region, and Morocco in particular, can play a growing role within these changing market dynamics if it focusses on reducing time-to-market and increasing productivity with the production of the final product.

To be able to play this role, however, the sector has to prepare ahead of time, upgrade and "learn to do things differently" (Interview with C2TM, February 2021). Morocco can play an important role, but the work has yet to be done, and the adoption of digital solutions are key for this purpose.[120] Given the distance at which firms in Morocco's garment sector find themselves from the technological frontier, a systematic and coordinated approach is needed to improve competitiveness.

In this context, the following policy guidelines emerge.

6.2.1 Assessment of local Industry 4.0 capabilities

The relatively new digitalisation strategy in Morocco and the release of the New Development Model as a guiding vision for the national development strategy have sparked dynamism in the garment sector as well. As discussed above, AMITH and the cluster organisations, together with ESITH, have also increasingly explored and introduced new technologies to the member firms. Yet, there has not been a systematic assessment of existing digital and automation capabilities within the sector. With financial support from the government and development cooperation partners, AMITH could engage in such a process. Information from such a detailed survey of capabilities and know-how could identify gaps and technology lead firms early on. This would facilitate further interventions

118 In addition, as one interviewee mentioned, most firms have become used to the idea that Morocco cannot face the competition coming from Turkey and Asia. Therefore, the firms that decided to stay in the sector relied on the same clients and accepted lower margins, unwilling to push the competition on their own (Interview with Mohamed Behnassi, February 2021).

119 Interview with C2TM, February 2021.

120 Interview with AMITH and C2TM, February 2021. As C2TM mentioned, "when the opportunity comes, if we are not ready, it will not wait for us."

to develop skills and support firms in identifying suitable digital and automation technologies in order to balance the advantages of low-cost manufacturing with the necessity to align production processes and business models to the needs of the market. The specific niche areas of lead firms could then be mobilised to present them as knowledge providers, demonstrating the benefits of engaging with innovative technologies.

6.2.2 Raise awareness

Related to the above, we found a general consensus among our interviewees concerning a lack of awareness regarding the benefits offered by digitalisation and automation in the garment sector. This lack of knowledge has also contributed to the unwillingness to invest in technological upgrading, in spite of the generous incentives to reduce the financial burden of investment.

The government has, however, already implemented investment support measures, covering up to 30 per cent of the cost of investment in new-generation equipment. Additional measures of support via MarocPME are being made available to firms, summing up to a generous offer from the government side. In addition to firms' reluctance to invest, many firms are not aware of existing support measures. As a result, government institutions often have to push companies to apply for these financial support instruments.[121]

Rising awareness through pilot demonstrations, workshops to discuss best practices and knowledge transfer from other companies should also be channelled through AMITH and the clusters. AMITH has also been active in finding new partners in France, Slovenia, Spain and Germany. Development cooperation stakeholders could also support efforts through specific programmes for knowledge transfer between German companies and Moroccan firms, for example. In addition, C2TM has also been working closely with the German Chamber of Commerce in Morocco (AHK Morocco) to identify German technology experts who can assist specific firms over a period of a few months with technological know-how. Continued support of such programmes for knowledge exchange and having experts explain and demonstrate the real benefits in terms of time and costs could play an important role in encouraging firms to invest in new equipment and digital processes.[122] Demonstrating the benefits will animate firms to upgrade and also create a demand for training and education institutes to follow up with new market-driven curriculums.

6.2.3 Develop and adapt skill development programmes

Training, especially at the technician level, as well as the expansion of the curriculums of education institutes are key for closing the skill gap identified by both policy-makers and firms. The programme mentioned above – aimed at bringing in technical experts from Germany to assist Moroccan firms with know-how – has been one such initiative to close this gap. Yet, a more systematic approach to training and re-training is needed, driven by

121 Interview with AMITH, February 2021.

122 The problem, as highlighted in the interview with AMITH and C2TM, is that even the firms that invested in new technologies do not use the tools at full capacity, as they are not entirely aware of all the functionalities of these machines or digital tools.

the long-term development vision for the sector and conceptualised in close coordination with the industry associations, the clusters and the lead firms.

Education institutes focus extensively on transversal skills such as management improvements. Yet, firms are expressing the need for more advanced technological know-how and applied technical skills. Therefore, a closer engagement between education institutes such as ESITH and Casa Moda and firms in the sector could contribute to refocusing course offerings and building up capabilities in new emerging topics such as e-commerce, digital marketing and digital design. Universities and research institutes such as Mascir and Cetemco could also develop research collaborations with the private sector to create new solutions and prototypes in order to improve productivity and efficiency in production.

Technical and vocational education and training programmes could also focus on developing skills for technicians, teaching workers how to use new machines and new processes, and integrating new technologies into the production process. A reassessment of the skill development programmes – in light of best practice technologies used in the sector globally – would be critical for this purpose.

6.2.4 Diversify export markets

Technological upgrading has been slow so far, also because most firms have a limited number of clients, produce locally and have not considered developing their own products or even diversifying their client base. Yet, the Covid-19 crisis has been a wake-up call for many. As such, efforts to further diversify export markets are necessary and could complement the above-mentioned policy guidelines. AMDIE's role in working closely with AMITH as well as development cooperation actors in Europe and North America is important. As the large majority of exports from Morocco go to Spain and France, diversifying to other countries in northern Europe, the United Kingdom and the US could bring new growth opportunities in the garment sector.

6.2.5 Attract investment in the sector

Lastly, over the last decade, the garment sector has seen limited foreign investment, especially in the denim sector. Attracting additional investment and identifying opportunities for joint ventures for knowledge transfer are necessary for enabling the Moroccan garment sector to move closer to the technological frontier and engage with new business models. It is key to further support AMITH's strategy of attracting investment to localise as much of the supply chain in Morocco as possible in order to reduce the time-to-market and make competitive price offers. For example, there are several firms that produce trousers but no local company to supply the materials; but with a local supplier, firms could produce on a shorter timeline (Interview with AMITH, February 2021).

6.3 General policy recommendations

Aside from the more specific areas of intervention listed above, we consider it necessary to also briefly stress the strategic roles that key stakeholders may play in this economic

transformation process: national policy-makers, international development agencies and lead firms.

Major strategy documents (such as the industrial development strategy) had to be renewed in 2020, and the NDM was meant to bring a change in paradigm with regard to economic development in Morocco. Therefore, especially since the changes in the development model are not as dramatic as was initially expected, a time for reflection should be considered. Specifically, since digital transformation and a potential reorganisation of GVCs are likely to bring new opportunities and challenges, **Moroccan policy-makers** need to reconsider whether the industrial development strategy can contribute in its current form to achieving key objectives such as job creation, diversification in export markets and technological upgrading, among others. Moreover, since Industry 4.0 calls for transversal skills and capabilities and is likely to generate spillover effects across the economy, cross-sectoral policy cooperation is essential. Therefore, while the Ministry of Industry should be in the driver's seat guiding this transformation, cross-sectoral cooperation and coordination should be continuously strengthened.

International development agencies are essential partners in this transformation process. Their role is essential, especially through technical development cooperation. Programmes such as the one that led to the establishment of the CCoA, which facilitates the creation of cross-sectoral capabilities in automation, play an important role in technological upgrading. As sectors such as the automotive sector gradually mature and domestic stakeholders become more capable of driving the upgrading process, international development agencies should shift their attention to lagging sectors such as the labour-intensive garment sector. It would be essential to provide technical assistance to transfer know-how and develop training programmes that are aligned with global technological and market trends.

Lastly, **lead firms** already present on the Moroccan market could further develop partnerships with European companies aimed at peer-to-peer learning, training and upskilling. International development agencies could support such efforts through platforms for knowledge exchange. The German Chamber of Commerce and Industry in Morocco – through its recent initiative to connect lead firms in Germany with potential local partners in Morocco – is a case in point.

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Annex: List of interviews and online events participation		
Garment sector		
DITF, Germany	Feb. 3, 2021	Prof. Alexander Artschwager
DITF, Germany	Jan. 22, 2021	Dr Thomas Fischer
Gerzi Textil Organization	Jul. 7, 2021	Prof. Yves-Simon Gloy
Dakota Garment Group, Hong Kong	Jan. 22, 2021	Hermann Leung
RWTH, Germany	Jan. 15, 2021	Dr Volker Lutz
Ecole Nationale Superieure des Industries du Textile et de l'Habillement (ESITH), Morocco	Feb. 3, 2021	Omar Cherkaoui Nabil Chakhchaoui Ayoud Nadi
Vita Couture, Morocco	Feb. 5, 2021	Mohamed Benajiba
Ibn Zohr University, Compliance auditor for textile and clothing, Morocco	Feb. 6, 2021	Mohamed Behnassi
Association Marocaine des Industries du Textile et de l'Habillement (AMITH)	Feb. 10, 2021	Radouane Lachgar
Masterfashion, Morocco	Feb. 12, 2021	Younes Fast
Denim and Fashion Cluster, Morocco	Feb. 24, 2021	Meryem Rachdi
Technical Textile Cluster (C2TM), Morocco	Feb. 25, 2021	Nabil Najim
Montepull, Morocco	Apr. 26, 2021	Hanane Tazi
International Trade Center (ITC) – MENATEX, Geneva	May 3, 2021	Matthias Knappe
PA Maghreb, Morocco	Mar. 26, 2021	Ikram Zeifi
Ibn Zohn University	Feb. 10, 2021	Mohamed Behnassi
Automotive sector		
Mundiapolis University, Casablanca	Feb. 12, 2021	Harun Ahmed Sabry
Protomain	Mar. 1, 2021	Saad Zabari
BASF	Mar. 2, 2021	Khaldoun Bouacida
SEW Eurodrive	Mar. 4, 2021	Mehdi Bnesouda
FEV North Africa	Mar. 4, 2021	Oussama Hafsi
Altran Maroc	May 22, 2021	Idriss Elasri
Alten Maroc	Jun. 17, 2021 Jan. 22, 2020	Amine Zarouk
Renault Maroc	Apr. 2, 2021	Mokhtar Homman
TE Connectivity	Jun. 21, 2021	Zakariaa El Hourch
McKinsey – Global lead on manufacturing & automotive	Jul. 7, 2021	Anil Kurana
Kostal Maroc	Aug. 12, 2021	Marius Valles
Policy-makers and development cooperation		
Ministry of Economy and Finance, DEPF, Morocco	Feb. 9, 2021	Taoufik Oukessou Rachida Ali Aoulad Afaf Hakam
Ministry of Industry, Trade, Investment, and the Digital Economy	Jan. 19, 2022	Selmane Lyagoubi
APEBI	Jun. 17, 2021	Amine Zarouk
AHK Morocco	Feb. 14, 2021	Andreas Wenzel
ADD	Jan. 29, 2020	Team
GIZ Morocco	Jan. 30, 2020	Team
Ministry of Industry, Morocco	Jan. 29, 2020	Team
GIMAS and Ministry of Industry, Morocco	Jan. 30, 2020	Team

Webinars and conferences

- MunichFabricStart. Don't be afraid of robots: How automation will change the fashion industry, 5 February 2021: https://www.youtube.com/watch?v=JZNf82rNng0
- WTIN – Zooming in on e-commerce in fashion and textile industry, 28 January 2021
- WTIN – Building supply chain resilience in a Covid-19 world with ERP, 10 March 2021
- Global Industry 4.0 Conference, Morocco, *Industrie du Maroc*, 27 January 2021: https://www.youtube.com/watch?v=9Y9rMLJlxrQ
- Mundiapolis University. Industrie 4.0 – *La transformation d'industrie et des systeme de production*, 9 April 2021
- *RDV de l'Industrie: Le secteur Textile et Habillement*, 30 June 2021: https://www.youtube.com/watch?v=m3mNUrmzhp0&t=3s
- AHK Morocco Business Talks: Automotive, 23 September 2021. Companies present in the discussion: Stahlschmidt Morocco (cables producer), Prettl Automotive Morocco (e-bikes parts and components and assembly), FEV North Africa, CCoA, International Transfer Center for Logistics GmbH: https://marokko.ahk.de/events/event-details/business-talks-automobile