WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

White Paper

The New Production Workforce: Responding to Shifting Labour Demands

In collaboration with Accenture

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Contents

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Foreword

The Fourth Industrial Revolution is transforming value chains in production industries with unprecedented speed and scale. Driven by a series of macro-level and industry trends, global value chains are being reconfigured, which significantly impacts workers and the types of the skills needed in industries ranging from textiles to chemicals and automotive. As a result, a new geography of production employment is emerging.

What will this new geography of production look like and what does it mean for workers, communities, policy-makers and business leaders today and tomorrow? What workforce disruptions and opportunities can we expect from this new geographic landscape? These are the central questions framing this white paper, which is a collaboration between the World Economic Forum and Accenture.

Our research reveals that there are widespread mismatches between where new production jobs are being created and where there are workers with the required skills. This creates a different kind of employment challenge for companies and nations that want to accelerate growth and elevate their production workforce.

To help create a constructive public-private conversation about how to address the challenges inherent in these shifts in production industries, our research attempts to quantify their potential impact on business, government and most importantly, workers. We aim to set the stage for multistakeholder dialogue and engagement around the societal issues that stem from the reshaping of production value chains. We believe that the urgency of the situation requires an institutionalized dialogue and new ways of finding solutions that are agile and put people first, to keep pace with today's rapidly changing production industries.

We consider this an ongoing journey, where speed, collaboration and innovation are the hallmarks for achieving positive outcomes for people, business and communities. And, we are only at the start.

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Executive summary

A combination of powerful forces – both technological and macro trends – are altering where and how goods are made and shifting labour demand. Jobs will be displaced by automation across global production value chains, but there will also be pockets of job creation within the wider manufacturing ecosystem.

However, widespread mismatches are likely between where new jobs are and where there are workers with the required skills, which creates a new employment challenge that could be particularly difficult for developing economies.

Production industries play a significant role in economies around the world. They are engines of growth and large employers. They contribute far more to research and development (R&D) than other industries. For these reasons, the performance of production industries is often regarded as an important indicator of an economy's strength. In recent decades, jobs in production industries have brought millions of workers in developing economies out of poverty and helped citizens in advanced economies move up to the middle class.

The geography of production remains high on the agenda of policymakers, who continue to view production industries as an enabler of social progress as well as an essential component of economic growth.

Today, production industries are undergoing massive change, which could potentially slow or even stop the progress made in recent decades. The Fourth Industrial Revolution is altering global production value chains. Value chains are becoming simpler. Sources of value are shifting, both across the value chain and geographies.

Companies are increasingly generating value outside the core manufacturing and distribution segments, for example in pre-production phases such as R&D, product development and after-sale services.

In addition, macro trends, such as concentration of demand and rising protectionism, are influencing where products are designed and built. These trends are leading to a shift in the geographical distribution of production jobs.

In this research, a model was built on macroeconomic data to create a set of scenarios for the purpose of identifying which regions and types of workers within the production ecosystem are most vulnerable to job disruption and displacement. Through this modelling, it is possible identify the places where workers are most in need of retraining to fit production industry demand. The findings reflect the impact of shifts in global value chains for five production industries – automotive, textile and apparel, chemicals, consumer electronics and industrial equipment.

The bottom line: We expect that employment losses in production industries will continue as companies automate work, but net losses will be smaller than some studies have predicted. The International Labour Organization (ILO), for example, has recently estimated that 61.6% of manufacturing jobs in the Association of Southeast Asian Nations region alone could be at risk.[1] According to scenario modelling, even as automation proceeds, demand for labour will increase in some parts of the supply chain and in some locations. An estimated 16% of jobs are susceptible to displacement in the five production industries analysed, after accounting for potential job gains that would arise from the same trends.

[1] Chang & Huynh, 2016.

Key terms

Fourth Industrial Revolution. "Characterized by a range of new technologies that are fusing the physical, digital, and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human." (Schwab K. , 2016)

Global value chains. These are the activities that contribute to creating the end product. This includes all activities from product conception (research and development), as well as sales and distribution channels to the customer, including marketing, outbound logistics and after-sales services.

Production industries. This includes all industries involved in transforming a material into an end product, from conception through manufacturing and delivery to the customer. For the purpose of this project, agriculture and extraction industries (for example, oil and mining) are not included.

Value-added activities. This includes all activities that add value to a product, in the form of physical value (assembly and other fabrication) or product design and development. In terms of the model, value add activities are defined in terms of US$ from the World Input-Output Tables (www.wiod.org), which traces back the value of activities completed across industries.

Value chain segment. This refers to the steps across the value chain that a product goes through from conception to creation and delivery to customers. These steps include research and development, design and development, inbound logistics, intermediate goods, supporting services, manufacturing, outbound logistics, marketing and after-sale services

Key findings

Shifting production footprints will alter the global demand for labour across value chains and geographies. Some value chain segments will be automated and others may consolidate as the line between traditional functions across the value chain starts to blur. The importance of non-production segments will increase across all geographies, as differentiation shifts to innovation and customer experience.

According to our model, the demand for workers in non-production segments and services could increase by up to 45%. Low labour costs may become less important and there may be 're-shoring' of production work to advanced economies. However, the jobs that are created will be different from the traditional production jobs that were offshored.

Skills mismatches are expected to increase. We identified two major characteristics in regions and countries that indicate a high potential for skills mismatches. First, are places with higher-skill but small production workforces, such as East Asia and Western Europe, where there is likely to be more demand for high-skill production workers than the labour market can supply.

Second, are places with large consumer markets. China and the United States could have the highest risk of skills mismatches, because demand for both high- and lower-skilled labour could rise by up to 43% due to the trends analysed, without taking into consideration the impact of automation.

Automation will continue to eliminate jobs. New jobs will require skills that displaced workers lack. It is expected that automation will continue to displace workers across the production value chain, particularly in South Asia and other developing economies. At the same time, jobs that will be created in production industries will require a different set of skills that exist in today's production industry labour force. This presents a significant challenge on two fronts: Dealing with the impact of workers displaced by automation, and addressing the need for widespread upskilling and reskilling of the production workforce.

The research highlights the massive and complex labour-market challenge developing across production value chains that employ an estimated 1.2 billion people today.[2] Labour demand will shift to different segments of the value chain and the types of skills needed across production jobs will also change. Workers of all skill levels will need to be able to work alongside intelligent machines and learn how to work with data. According to recent studies, human strengths such as problem-solving, leadership and creativity will be more important to employers than manual dexterity or the ability to manage budget spreadsheets, which are talents that machines can easily match.[3]

Getting the right type of workers trained in required skills in time and in the places where they will be needed must be a top priority for companies and the economies that want to encourage production-related employment. The scale of the upskilling and reskilling needed will require multistakeholder support and governance, as well as new approaches to deliver programmes rapidly to millions of workers. Coalitions of governments, employers, unions and other stakeholders will be essential. The advanced digital technologies that are remaking production industries – from machine learning to virtual reality – should be employed to devise and execute the skills training that countries around the world will need.

[2] Derived from the baseline established by model. See Appendix 3: Baseline data by industry, geography, and value chain segment.
[3] Shook & Knickrehm, 2017.

Current context: The geography of production labour today

Five production industries were selected as an illustrative samples of how the production workforce might be affected by changes in the geography of production. The research considers value added (in US$) along production value chains and the associated number of people engaged[4] globally in five industries – automotive, textile and apparel, consumer electronics, chemicals, and industrial equipment – in eight geographic regions[5].

Through this analysis, how and where workers of different skill levels are employed were estimated. This data serves as the baseline for the simulation of how industry trends such as automation and changing consumer demand, as well as global macroeconomic trends such as protectionism, could affect demand for different types of labour across geographies and value chain segments. This enabled the authors to contrast the geography of production today with that of tomorrow.

The global value chain has been defined by the inflows and outflows of value-added activities globally. Global data[6] is used on five identified industry value chains in the model. By tracing the contribution of all industries backward from the end product to the beginning of value-added activity, it is possible to estimate how much value is associated with each of eight value chain segments. Figure 1 shows the full production value chain as traced through the world input output tables.

[4] For further detail on the development of the model, please refer to Appendix 1: Technical model overview
[5] See Appendix 2: Geography breakdown included in model for list of countries and associated regions
[6] World Input-Output Database, 2016.

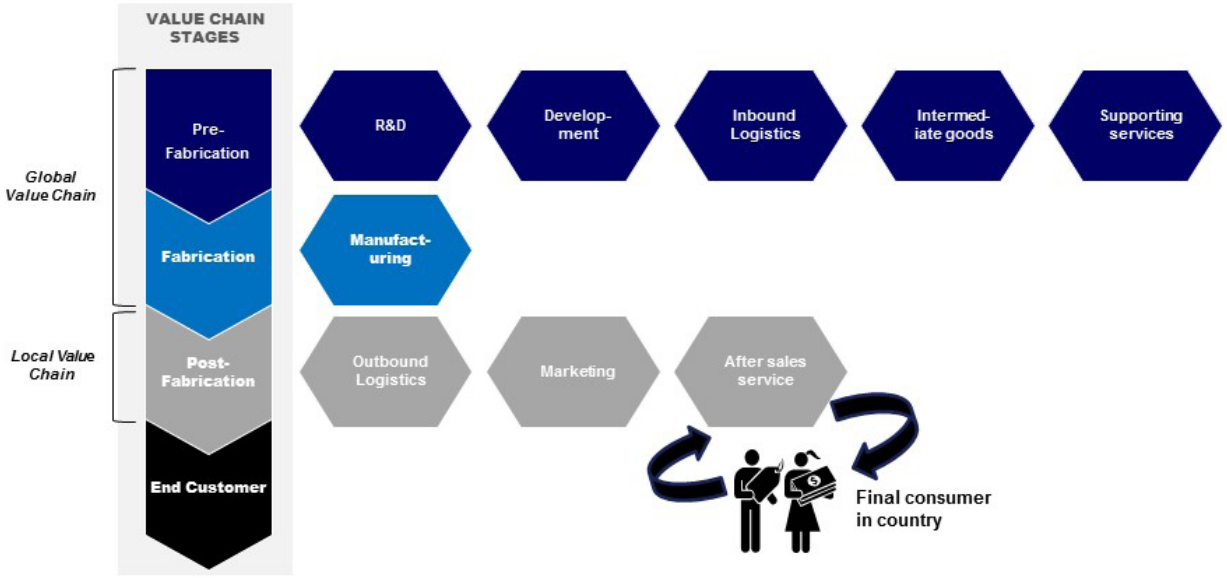
What is the difference between a global industry and a global value chain?

A global industry includes those activities and workers that are directly employed and reported in a specific industry or sector. For example, the automotive industry will only include companies with the primary purpose of manufacturing automotive parts or finished goods. It will not include electronics companies that contribute electronic systems into automobiles because those companies would be considered part of the electronics sector.

A global value chain refers to all activities related to the production of a finished good, regardless of the industry classification.

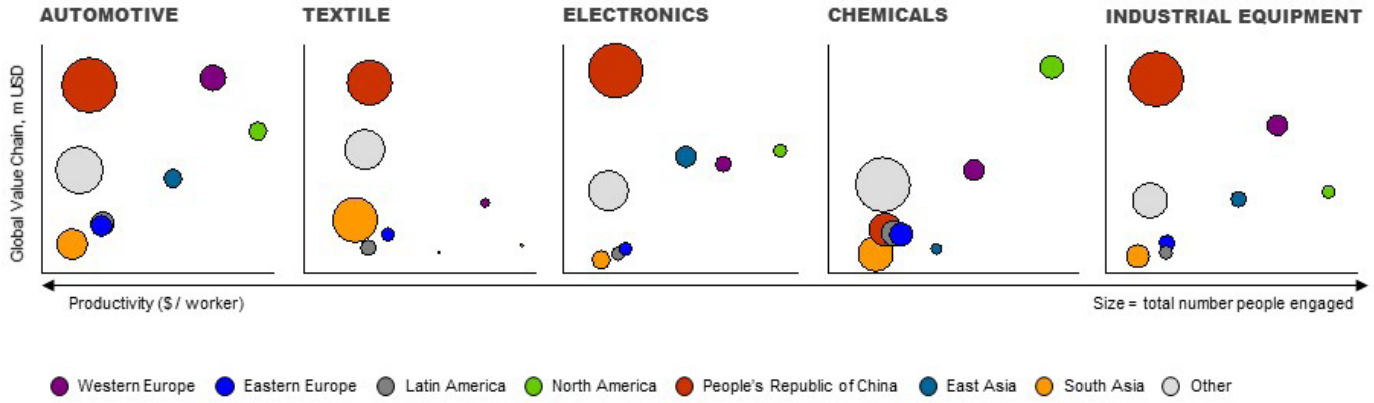
By exploring production from a global value chain perspective, we can understand the full reach of a given production industry across geographies and workforce activities. Having visibility of all industries contributing to a single value chain provides a unique insight to what the impact of industry-specific trends will be on the related global workforce.

Figure 1: Global value chain stages and segments



When comparing the five industries, the research revealed that the current distribution of employment, both by skills and geographies, is similar across most industries, with the notable exception of chemicals. The chemicals industry is a continuous-processing industry and by nature is highly capital-intensive, which is why the value chain profile looks different from other manufacturing industries. This is illustrated in Figure 2, which provides an overview of the geography of production workers and associated value chain and productivity by industry.

Figure 2: Global summary for five industries



The current state of the five focus industries

To understand how global employment in production industries is likely to evolve, the current state of the five focus industries as a baseline was used. These industries directly and indirectly employ 315 million workers globally and represent a wide range of business models and value chains, from knowledge-intensive industries, such as automotive and consumer electronics, to labour-intensive industries, such as textiles and apparel.

Automotive industry

The manufacture of passenger vehicles

The automotive value chain engages 67.5 million people around the world and is considered a knowledge-based industry. Companies compete on design, engineering and the ability to manage highly complex production systems and supply chains. The value chain engages a wide mix of workers of differing skill levels, which varies by geography. Production in advanced economies tends to be more automated.

For example, the People's Republic of China, which is the largest auto market, employs most of its low-skilled labour domestically. The People's Republic of China also has the highest proportion of low-skilled workers overall – 44% of workers in the Chinese auto market are in low-skill jobs, compared with 25% in Germany and 22% in the United States. Germany, which has the smallest domestic labor force of the automotive markets compared in the research, is the most reliant on overseas labour of all skill levels, which accounts for 62% of the workforce engaged in the automotive value chain in Germany).

The value chain

Research and development. All activities related to the research & development of a new product, including changing or customization of a product.

Design and development. All activities related to the development of a product to move from proof of concept to a production product. This includes the design and development of the manufacturing process.

Inbound logistics. All activities related to the transportation, storage, distribution and receiving of input materials for the manufacturing process.

Intermediate input materials. All production activities related to producing input materials for the manufacture of the end-product.

Supporting services. All activities related to third-party services that support the ongoing operations for the manufacturing floor.

Manufacturing. All activities related to the physical production of the end product, from start of the production process to the end when it is a finished product. It includes primary packaging of products, but not secondary, which is included in logistics

Outbound logistics. Similar to inbound logistics, all activities related to the post-fabrication transportation, storage and distribution of finished goods.

Marketing. All activities related to the sales and marketing of the final product.

After-sale services. All services related to post-sales activities.

Apparel and textile industry

The manufacture of textiles and apparel, primarily clothing and shoes

The apparel and textile value chain was one of the first industries to take advantage of labour arbitrage between high- and low-wage economies. A significant amount of the workforce employed in textiles and apparel is in developing economies, particularly in the People's Republic of China, Bangladesh and other parts of Asia. Most high-skill and high value-added work, including design, R&D and services, remains in advanced economies, which helps companies keep up with rapidly changing tastes in the largest consumer markets.

Asia accounts for more than 60% of the 123.4 million workers engaged in the value chain globally; 95% of Asian textile workers are in low- and medium-skill jobs; only 5% are high-skill. A quarter of apparel and textile R&D and design jobs globally are in advanced economies in North America, Western Europe, and East Asia (Japan, the Republic of Korea), while fewer than 5% of the sector's manufacturing workers are employed in these geographies.

Consumer electronics

The manufacture of electronic devices intended for private use

Innovation, product development, R&D and low-cost production, are key to competing in consumer electronics. The high-skill development work tends to take place in innovation hubs such as Silicon Valley in California, Singapore, Berlin, Stockholm, and Bangalore. In 2017, 14 of the top 20 technology hubs in the world were in North America and Western Europe.[7] More than half of the global value generated by the consumer electronics value chain comes from these geographies. However, they only employ 16% of the global consumer electronics workforce. Lower-value production work has moved almost entirely to the People's Republic of China, India and other developing economies, which employ 85% of the value chain's low-skill workers.

Chemicals

Process manufacturing that turns raw materials into chemical mixtures and compounds

The chemicals value chain is very different from that of the other value chains analysed. Chemical manufacturing is highly capital intensive and dependent on large facilities that operate with little human intervention. Many of the production processes are already automated, which is reflected in the industry's modest employment, which is about 14 million employees globally, relative to its $559 billion per year in value added. Higher value-added work is concentrated in advanced economies, with employees in Western Europe and the United States accounting for 55% of value added.

Nearly 80% of the global workforce is employed in the People's Republic of China, Latin America and other developing economies. North America generates 37% of overall value, with only 7% of the global workforce, which reflects the high degree of automation and concentration of high-value work there. One-third of the employees working in the North American chemical value chain are highly skilled, compared with 7% in the People's Republic of China, where almost 56% of chemical workers are low skilled.

Industrial equipment

All goods and services related to the production and upkeep of capital equipment and machinery used across all sectors

Chinese companies have become the dominant force within the global industrial equipment manufacturing value chain, starting in the 1980s as the offshoring site for lower-value manufacturing activities of companies based in advanced economies.

Today, a large share of value creation occurs in advanced economies in Western Europe, North America, and East Asia, but the People's Republic of China has become the leading country in industrial equipment, both in terms of employment and value added, employing 46% of all workers and generating 31% of value added.

Western Europe and North America are the traditional powerhouses in the global value chain, contributing 23% and 13% of global value added, respectively. Combined, they employ only 11% of the global workforce, but 25% of the industry's workers in Western Europe and North America are high-skill, compared with just 8% in the People's Republic of China. In the People's Republic of China, 53% of workers in the industry value chain are low-skill and 40% are middle-skill.

Table 1 shows the baseline of the current workforce for the five selected industries across geographies and value chain segments.

[7] Alfaro, 2015.

Table 1: Global workforce landscape by geographic cluster

Industry	Value added (trillion USD)	Number of people engaged (millions)	Number of people engaged by geography (millions)							
			Western Europe	Eastern Europe	Latin America	North America	People's Rep of China	East Asia	South Asia	Other
Automotive	$2.2	67.5	5.1	4.2	4.3	2.8	23.0	3.3	7.3	17.5
Apparel and textile	$1.2	123.4	2.1	4.1	5.3	0.6	39.1	0.9	39.9	31.5
Consumer electronics	$1.2	38.0	5.6	3.8	2.6	2.3	33.2	3.7	6.1	15.2
Chemicals	$0.6	14.0	1.9	1.4	1.5	1.5	17.3	2.7	2.4	9.5
Industrial equipment	$2.2	72.5	0.8	1.0	1.3	1.0	2.1	0.3	2.2	5.2

Industry	Number of people engaged by value chain segment (millions)							
	R&D	Design and development	Transportation	Warehousing	Distribution	Supporting services	Intermediate inputs	Manufacturing
Automotive	0.2	0.6	3.6	0.8	12.9	12.5	21.1	15.8
Apparel and textile	0.0	0.2	2.9	0.5	12.1	7.6	47.6	52.5
Consumer electronics	0.1	0.3	1.6	0.3	6.7	7.0	10.0	11.9
Chemicals	0.0	0.1	0.8	0.2	2.3	2.4	4.9	3.2
Industrial equipment	0.1	0.5	3.8	0.7	10.5	13.9	22.3	20.8

The current geography of production employment

Despite globalization, employment in production industries remains largely tied to geographic markets. A high percentage of workers who participate in the production of end products are located in the markets where the goods are consumed. For example, of all automotive products consumed in the US, only 28% of value added is created outside of the US, which makes the value chain less global than might be assumed. A large proportion of the global production workforce is in developing economies, predominantly in Asia, where their output serves both fast-growing local markets and export markets (Figure 3).

Western Europe

Western Europe and Australia comprise an estimated 5% of the workforce across the five sample industries, employing 15.4 million workers. Within this region, 33% of the workers are engaged in the automotive value chain, 14% in textiles, 36% in machinery and 12% in electronics. The remaining 5% are in the chemicals sector.

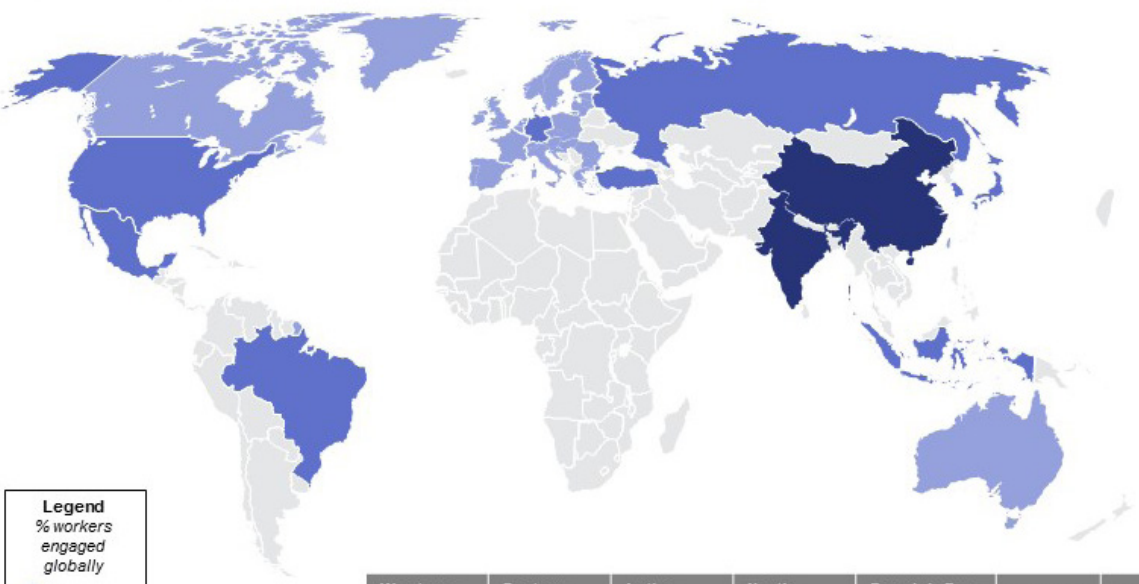
Of this workforce, nearly half (48%) are medium-skill, 24% are high-skill and 28% are low-skill. Most of the medium-skill workers are engaged in the manufacturing value chain segment. The highest concentration of high-skill workers is in R&D, design and development, and supporting services, which have a small proportion of low-skill workers.

For the purpose of this analysis, Australia has been grouped with the Western Europe geographic cluster. This is due to the similar production industry and workforce profile that Australia has with Western European countries.

Eastern Europe and Turkey

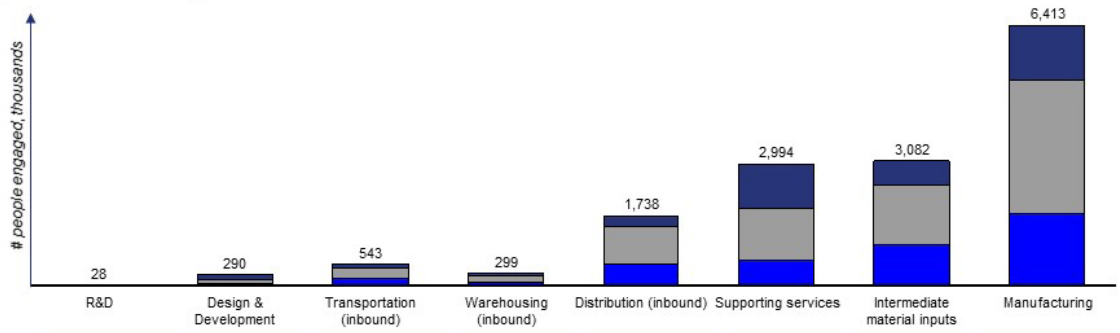
This region includes major Eastern European countries, as well as Turkey and Russia. The region accounts for nearly 5% of employment in the five global value chains, about 14.5 million workers. The production workforce in this region is almost equally divided among automotive, textiles, and industrial equipment value chains – 29%, 28% and 26% respectively. A comparatively small share of workers is employed in electronics and chemicals (10% and 7% respectively).

Figure 3: Geography of production today



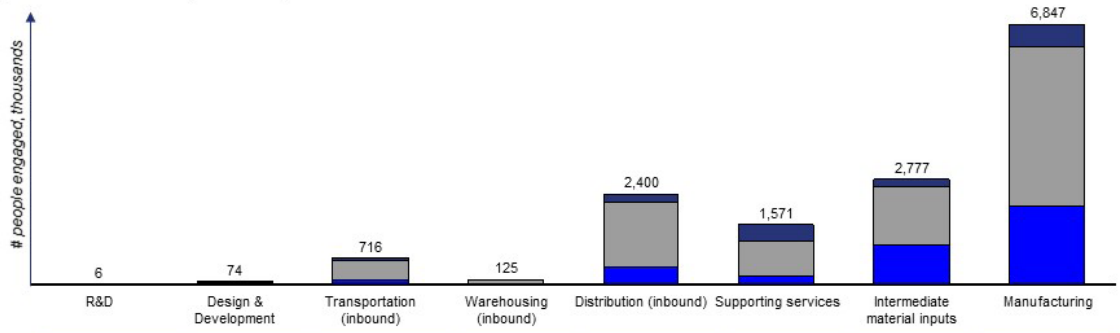
	Western Europe	Eastern Europe	Latin America	North America	People's Rep of China	East Asia	South Asia	Other
# workers engaged, millions	15.4	14.5	15.0	8.2	115.7	10.9	57.9	79.0
% of workers engaged	5%	5%	5%	3%	36%	3%	18%	25%

Figure 4: Western Europe value chains and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	28	290	543	299	1,738	2,994	3,082	6,413
High Skill (%)	45%	45%	19%	18%	16%	37%	20%	21%
Medium Skill (%)	38%	39%	50%	52%	53%	42%	47%	51%
Low Skill (%)	16%	16%	31%	30%	31%	21%	33%	28%

Figure 5: Eastern Europe and Turkey value chain and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	6	74	716	125	2,400	1,571	2,777	6,847
High Skill (%)	42%	41%	9%	9%	10%	28%	7%	8%
Medium Skill (%)	50%	42%	73%	75%	71%	58%	55%	61%
Low Skill (%)	8%	16%	18%	16%	19%	14%	38%	31%

Only 11% of the production labour force in the area is high-skill, and they are concentrated in R&D, design and development, and supporting services. These value-chain segments employ relatively few workers in the region; manufacturing accounts for nearly half or all production jobs.

Latin America

In Latin America, the two largest economies were considered – Mexico and Brazil – which employ nearly 5% of the global workforce in the five industry value chains, about 15 million workers. The mix of the production labour force in Latin America follows the pattern of other developing regions, with few high-skill workers (10%), 47% medium skill, and 42% low skill.

The most dominant industries in this region are automotive (29%) and textile (35%); industrial equipment accounts for 17%, electronics employs 10% and the chemicals value chain employs 9% of the workforce. Similar to other emerging markets, the manufacturing value chain segment is the largest in this region, employing 48% of the workforce.

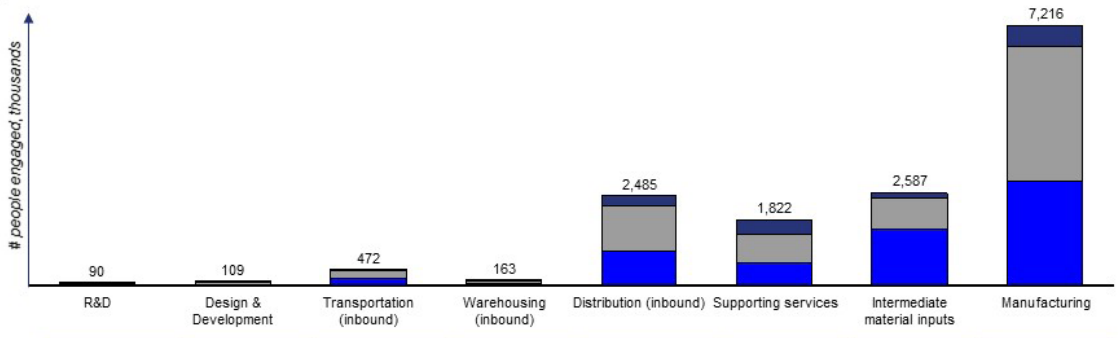
North America

Only about 3% of the global labour force in the five value chains – about 8.2 million workers – are employed in the United States and Canada, making this the smallest production workforce of any region. The skills profile is virtually opposite of developing economies, with low-skilled workers making up just 8% of the workforce.

High-skilled workers account for 31% of employment and 61% of North American production workers in the five industry value chains are middle-skill. Automotive, industrial equipment, and electronics are the largest value chains in North America, engaging 35%, 28% and 18% of the workforce, respectively. Textiles is the smallest at 8%; chemicals employs 12%.

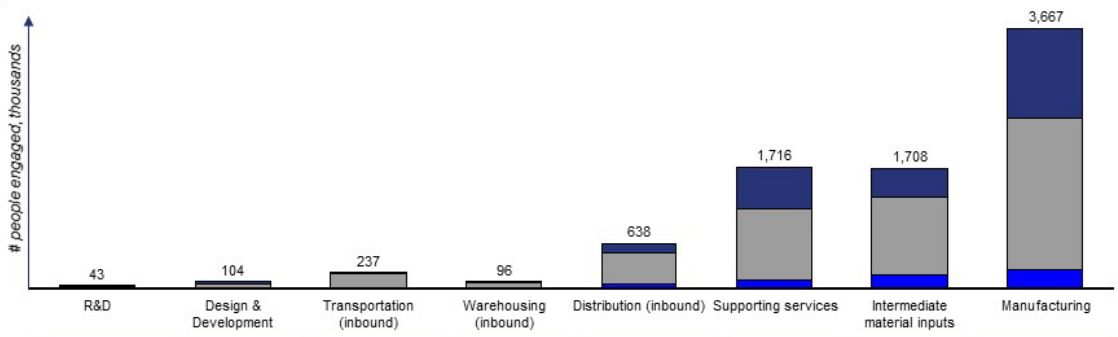
The manufacturing segment of the value chain employs the most production workers in North America, but just 7% of these workers are low-skill; 58% are medium-skill and 34% are high-skill. By contrast, in the People's Republic of China and South Asia 57% and 56% of manufacturing workers, respectively, are low-skill.

Figure 6: Latin America value chain and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	90	109	472	163	2,485	1,822	2,587	7,216
High Skill (%)	29%	30%	16%	15%	10%	10%	22%	6%
Medium Skill (%)	48%	46%	44%	49%	71%	52%	44%	33%
Low Skill (%)	23%	24%	40%	37%	39%	34%	61%	40%

Figure 7: North America value chain and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	43	104	237	96	638	1,716	1,708	3,667
High Skill (%)	49%	49%	16%	15%	19%	35%	24%	34%
Medium Skill (%)	45%	45%	76%	76%	72%	58%	65%	58%
Low Skill (%)	7%	7%	8%	9%	8%	7%	11%	7%

The People's Republic of China

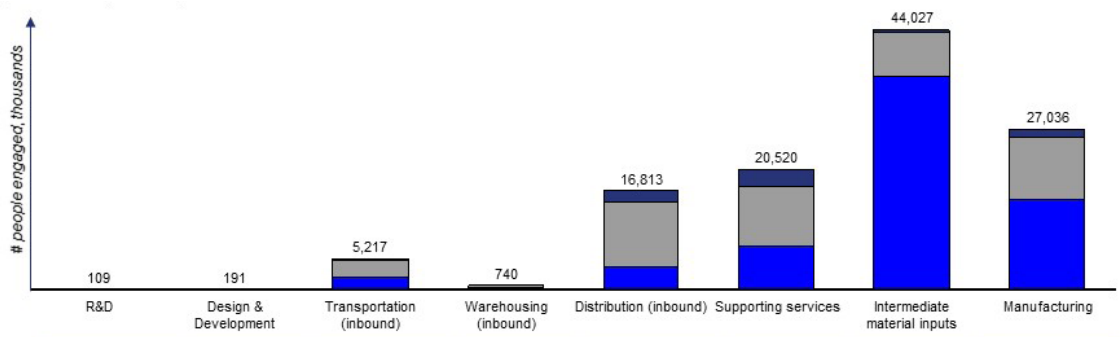
The People's Republic of China employs the most workers in the five global value chains, employing 36% of the analysed workforce, or about 115.7 million workers. Only 6% of these workers are high-skill, while 36% are medium-skill and 58% are low-skill. As part of the Made in China 2025 strategy, the Chinese government hopes to move more of the production labour force into medium- and high-skill work to help the country raise productivity and move into higher value-added production work.

Today, China has the largest number of low-skill workers in the five value chains, about 66 million people. The largest value-chain segment is input materials, not manufacturing of finished products. Despite its reputation for manufacturing, more of the People's Republic of China's value added remains in intermediate components, rather than end products across the five value chains. Textile and industrial equipment value chains together make up for almost two-thirds of the workers in the five value chains, engaging 34% and 29%, respectively. Automotive accounts for 20%, consumer electronics 15% and chemicals 2%.

East Asia

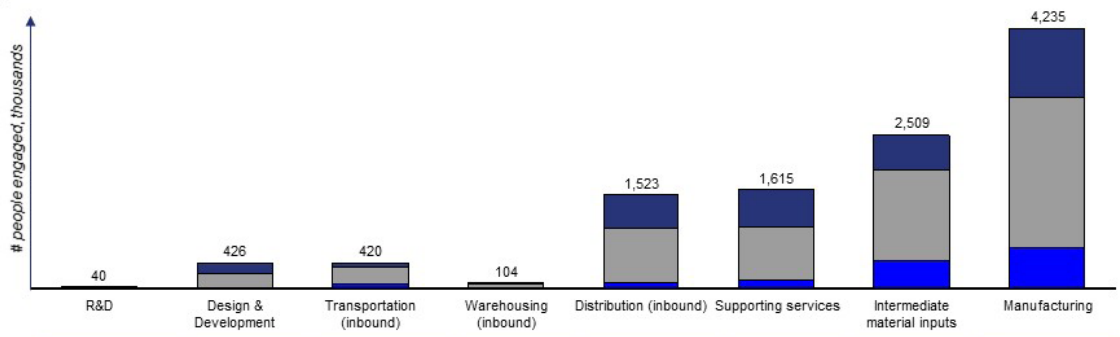
East Asia (Japan and Republic of Korea), similar to North America, accounts for a little over 3% of the overall workforce in the five value chains, with about 10.9 million workers. The skills profile of the workforce in East Asia is also similar to that of North America, with a relatively low proportion of low-skilled labour (14%), 57% medium-skilled, and 29% high-skilled. The industrial equipment, automotive and consumer electronics value chains employ the most production workers, 34%, 30% and 25%, of the labour force, respectively. Textiles and chemicals employ significantly fewer workers – 8% and 3%, respectively. Additionally, the countries in the East Asia geographic cluster are relatively high-skilled and high-cost locations.

Figure 8: The People's Republic of China value chain and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	109	191	5,217	740	16,813	20,520	44,027	27,036
High Skill (%)	24%	24%	7%	10%	12%	15%	1%	5%
Medium Skill (%)	38%	38%	52%	48%	65%	49%	16%	39%
Low Skill (%)	38%	38%	41%	43%	22%	36%	82%	57%

Figure 9: East Asia value chain and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	40	426	420	104	1,523	1,615	2,509	4,235
High Skill (%)	59%	43%	18%	28%	36%	38%	23%	26%
Medium Skill (%)	36%	53%	67%	58%	57%	54%	59%	58%
Low Skill (%)	5%	4%	15%	14%	7%	8%	18%	16%

South Asia

The South Asia geographic cluster, including India and Indonesia, is one of the largest regions included in the analysis, accounting for 18% of the workforce across the five value chains engaging 57.9 million workers. The skills profile of South Asia is similar to that of the People's Republic of China's in that medium- and low-skill labour make up 92% of the total analysed workforce, with 33% of the workforce engaged in medium-skill labour and 59% in low-skill labour.

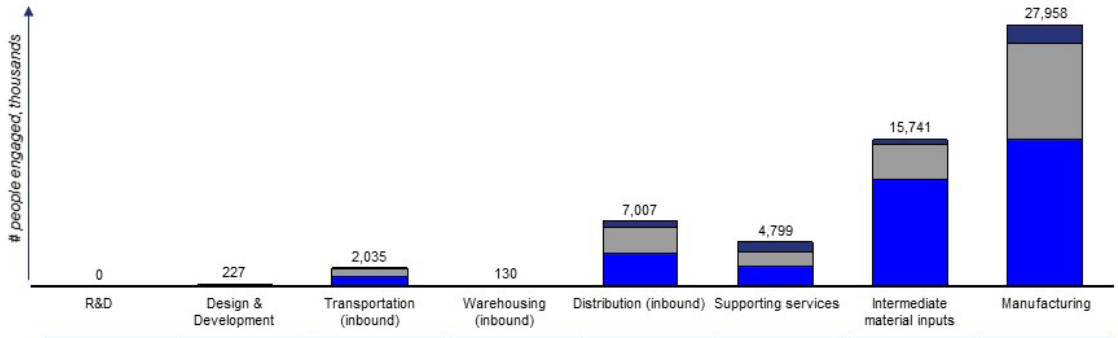
Only 8% of the total South Asia workforce is engaged in high-skill labour. South Asia is overwhelmingly dominated by the textile value chain, with 69% of the workforce analysed engaged in the textiles value chain. The automotive sector accounts for 13%, industrial equipment 11%, and both electronic and chemicals each engaging about 4% of the workforce.

Other developing economies

This group, which includes more than 100 smaller developing economies, accounts for less than 20% of global value added in the five value chains, and about 25% of the workforce, or about 79 million people. The distribution of skills and industries is similar to the geographic clusters of South Asia and Latin America.

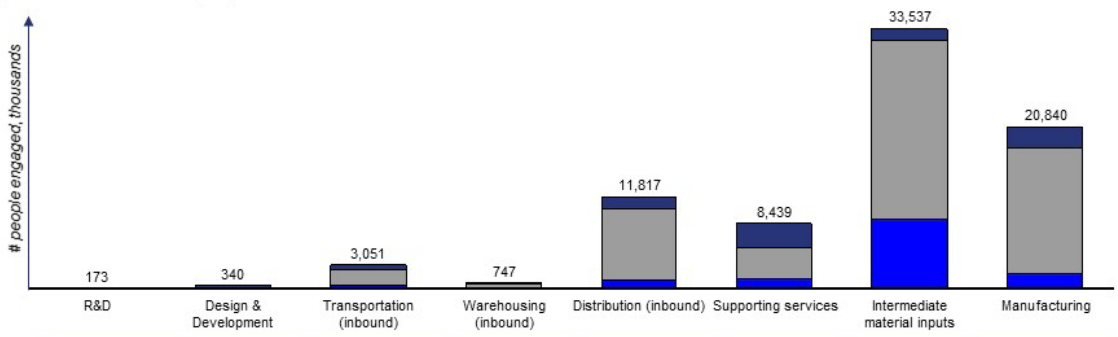
Nearly three-quarters of the labour force (73%) is medium-skill, 18% is low-skill and 13% is high-skill labour. The largest percentage of workers – 40 – is employed in the textiles value chain. Automotive employs 22%, industrial equipment 19%, electronics 12%, and chemicals 7%. Across these economies, the largest number of production workers are employed in the intermediate input materials segment of the value chain.

Figure 10: South Asia value chain and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	-	227	2,035	130	7,007	4,799	15,741	27,958
High Skill (%)		55%	7%	7%	9%	22%	3%	7%
Medium Skill (%)		32%	41%	37%	41%	33%	24%	36%
Low Skill (%)		13%	52%	56%	50%	45%	73%	56%

Figure 11: Other developing economies value chain and skills profile



	R&D	Design & Development	Transportation	Warehousing	Distribution	Supporting Services	Intermediate material inputs	Manufacturing
No people engaged, thousands	173	340	3,051	747	11,817	8,439	33,537	20,840
High Skill (%)	71%	71%	17%	17%	14%	37%	4%	13%
Medium Skill (%)	24%	24%	58%	58%	77%	48%	69%	77%
Low Skill (%)	5%	5%	15%	15%	9%	15%	27%	10%

Key trends: The industry and macro trends shifting global production employment demand

A series of trends from within production industries and in the global economy are influencing the type of labour and skills needed and where workers will be employed. Through a series of expert interviews and workshops, nine major trends were identified that are impacting global production value chains today.

Automation and digitization are the most pervasive and powerful forces acting on value chains and labour demand, often enabling other trends such as customization. While automation and new technologies raise productivity and enable new processes within the factory, the Fourth Industrial Revolution is also influencing how other segments of the value chain connect and how the various players interact across the ecosystem.

Workers are responding in a relatively positive way to technology advancements.[9] According to an International Trade Union Confederation poll, an estimated 70% of the global workforce believes technology will create new jobs, while 80% believe new technologies contribute to better labour conditions for workers.

[9] International Trade Union Confederation (ITUC), 2017.

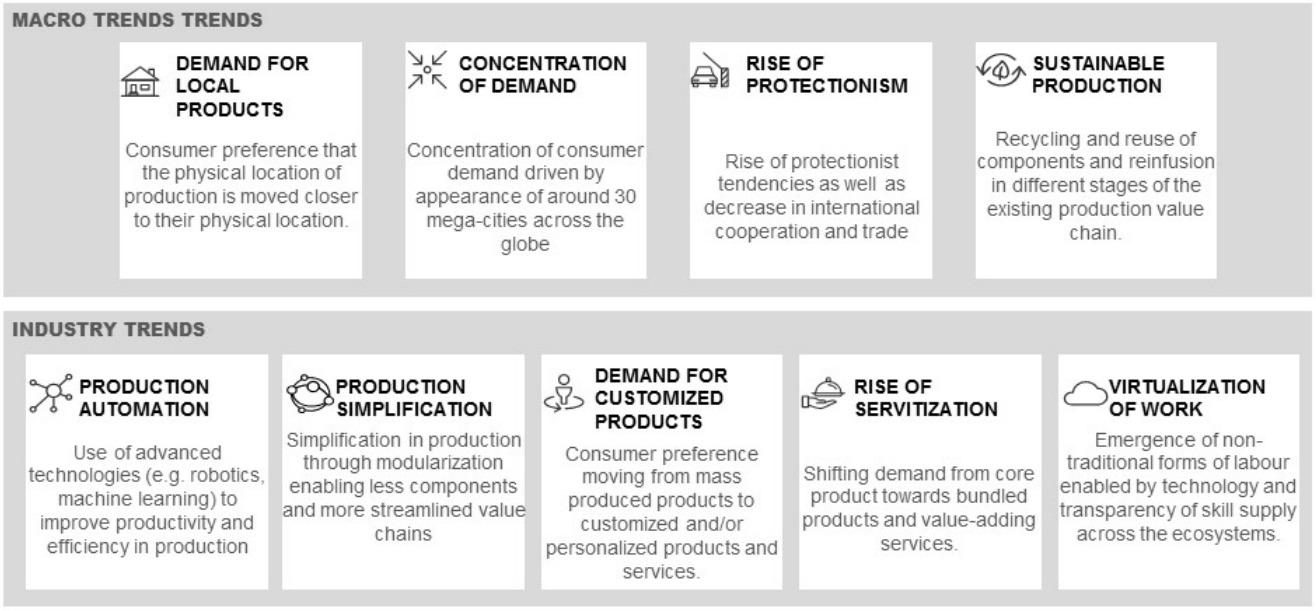
Industry trends: The Fourth Industrial Revolution

Production industries are at the heart of the Fourth Industrial Revolution. This involves the widespread use of digital technologies and connectivity of systems and value chain segments across manufacturing. Companies are scrambling to catch up with the pioneers in their industries. The Fourth Industrial Revolution accelerates and enables critical trends that will drive labour demand in production industries.

– **Production automation.** Automation of production processes has been ongoing for years, but the pace of automation is accelerating as technologies such as robotics become more affordable and the range of tasks that can be handled by robots and computers expands. The most obvious impact will be continuing pressure on factory jobs. However, the focus on automation increasingly extends beyond the shop floor.

  Artificial Intelligence will be used to automate tasks across production companies, including work in R&D, marketing, finance and customer service. It is part of the wider digitization trend that is changing how companies work. Similar to companies in other industries, production companies are undergoing digital

Figure 12: Four macro trends and five industry trends



transformation, using data, online systems and other digital tools to streamline processes and enable new business models.

– **Production simplification.** Simplification reduces production costs by designing products with fewer, more interchangeable and lower-cost components, which requires less assembly work. Production simplification is enabled through advances in materials as well as new production methods, such as additive manufacturing (3D printing). Aerospace manufacturers, for example are now able to print intricate metal components that in the past would have been assembled from multiple cast parts. Production simplification affects costs and employment in the factory and reduces complexity across the value chain, resulting in a change in the need for non-production labour. Production simplification is heavily dependent on medium- and high-skill talent to design components and run advanced production machinery.

– **Demand for customized products.** The connected supply chain makes it practical to offer customized products. For example, consumers can choose custom colour combinations or extra features on sports shoes and other apparel items. Nike's digital retail experience enables consumers to order customized sports shoes using in-store kiosks. [10] With new technologies, a wider range of manufacturers will be able to offer customized products.

  Connectivity and advanced data analytics also give manufacturers early indications of changing customer needs, so they can exploit changes in customer preferences quickly. Shifting value chains, new operating models and the rise in consumption in developing economies will also move demand for workers of varying skill levels to different places around the globe. Digital technologies and the trend to bring manufacturing closer to the customer will require a new set of skills.

– **Rise of servitization.** Traditionally, companies in production industries have focused primarily on building and selling their physical products. Today, the basis of differentiation and competitive advantage is shifting and expanding. According to a survey, 82% of European manufacturing companies plan to expand services offerings as part of their competitiveness agenda.[11]

  Companies are starting to move to end-to-end offerings, including a product, software applications and associated services. For example, Caterpillar is moving from simply providing farm and construction equipment to offering customers end-to-end solutions that include an expanding range of after-market services. Companies across all industries find that they can increase sales and build customer loyalty by improving the experience of owning and using their products. These trends will drive demand for workers with skills in service functions.

[10] Demodern Digital Agency, 2017.
[11] Oxford Economics, in partnership with PTC, 2013.

– **Virtualization of work**. Ubiquitous connectivity also makes it possible for production industry companies to employ workers remotely, either full-time employees or workers who are engaged on a contract basis. Rather than attempt to move a software engineer halfway around the world to fill a job, a manufacturer can access people with the appropriate skills by employing such a worker remotely. A virtual workforce can also include freelancers, who are hired on a temporary basis for a project, or "gig economy" workers, who offer their services via online talent platforms.

  An example of how the gig economy is disrupting traditional production value chain work is in the transportation sector. The advent of ride-sharing services such as Uber and Lyft has created new opportunities for freelancers. In commercial transportation, local delivery truck driving is one of the top 10 growth categories for freelancers, according to a recent survey by CareerCast,[12] a freelance talent platform. These flexible work arrangements can help employers fill growing skill gaps on a short-term and low-risk basis. The virtualization of work will also give rise to more complex relationships among workers, employers and labour organizations as informal work becomes more commonplace globally.

Macro trends: A step back from globalization and the rise of developing economy consumers

Global economic growth continues to shift from advanced economies to developing economies in Asia, Africa and other parts of the world. At the same time, the globalization that has spread production jobs across continents appears to be in retreat. Cross-border investments and other flows have slowed since the global financial crisis, and the rise of nationalist political parties could lead to outright protectionism.

The pressures on the environment are becoming harder to ignore as the United Nations Sustainable Development Goals are driving production industries to look at manufacturing in a sustainable and responsible way for the future. The combined forces of these macro trends will potentially have significant impacts on where and how production industries operate and consequently on their global employment footprints.

– **Demand for local products.** Consumer demand for local products is particularly important in specific product segments of goods, apparel (luxury brands), and in food and beverage categories. For example, the United States is seeing a trend towards "Made in USA" branded apparel. This trend is bolstered by rising

[12] Career Cast Temporary & Part-Time Network, 2017.

production costs overseas.[13] Labour in North America will not be cost-competitive with emerging economies, but consumer willingness to pay a premium for locally made products is causing an increase in small and medium enterprises[14] located in local markets.

This trend is being enabled through technology, both by creating a way for entrepreneurs to access consumers through online platforms and by reducing the costs of production through more efficient production technologies. Most of the businesses that are benefitting from this consumer trend are small and medium-sized enterprises (SMEs), which means the scale and impact on the global workforce is relatively small. However, this trend will create pockets of skills demand for specialized production skills that might not be readily available.

– **Concentration of demand.** Growth of megacities, particularly in developing countries, is leading to an unprecedented concentration of demand as large numbers of people move to these urban centres. Over the years, foreign investment has transformed developing economy megacities from largely unproductive and over-populated metropolises into production ecosystems, built mainly on exporting goods to advanced economies.[15] With growing wealth, more of this production is consumed locally. Rising skill levels in the labour force means that more production activities can also be performed in megacities. The Future of Production in ASEAN report published by the Future of Production initiative provides some additional insights on the impacts of megacities on production.

– **Rise of protectionism.** In many places, public sentiment and policy are moving towards protectionism. This is likely to have minimal impact on jobs in the near term, but could cause a net negative effect on jobs globally long term. The overall effect would be to shift production and related employment to countries that have high productivity and can fill demand with fewer employees.

  For example, if a highly productive country such as Germany adopts policy measures that incentivize re-shoring of jobs that have been sent overseas as cost-savings initiatives, the work will return to Germany. However, it is likely that only a fraction of the jobs will return. This is due to fact that Germany can be equally productive with fewer people because advanced technologies enable streamlined processes.

  The protectionism trend is occurring more often in advanced economies, which tend to be more mature in technology and process development, and therefore more productive. For companies to remain cost-competitive and return work to advanced economies where the cost of labour is higher, they will do so with increased automation to minimize the impact to their overall cost base.

– **Sustainable production.** As the world population grows and sustainable practices become more important across the value chain, manufacturers are looking for ways to minimize the environmental and societal impacts of production. For example, as part of its sustainability strategy, Unilever has introduced a programme called Lifecycle Assessments to better understand how their products currently impact the environment, from the materials used to how they are discarded. This enables Unilever to design products in a more sustainable way.[16]

  The programme creates a need for new product designs, as well as constantly reviewing and improving the environmental profile of existing products. Such programmes will result in a fundamental shift in the amount and type of products that are produced, potentially reducing demand for production labour, but raising demand for higher-skill workers in design and R&D. For further insights on accelerating the future of sustainable production, see the white paper, Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation, published to support the System Initiative on Shaping the Future of Production.

[13] Wee, 'Made in USA' fuels new manufacturing hubs in apparel, 2013.
[14] Wee, Wlcome Home, 'Made in U.S.A.' on the Rise, 2013.
[15] Bugliarello, 2008.
[16] Unilever, 2017.

Research findings: The likely impact of industry and macro trends on global employment in production industries

To understand how these trends might play out and impact the patterns of employment across global production value chains, a model has been created that simulates the impact that such trends might have on the five global value chains. Various scenarios have been simulated based on a combination of trends. This modelling also enables us to predict where various value chain activities might increase or disappear.

Each of these trends impacts individual value chains and geographies in unique ways. We have modelled the potential impact of individual trends on each value chain and then looked at them in combination to create an overarching scenario for the value chain.

The model estimates the isolated and combined potential effects of five industry trends: automation, localization, customization, protectionism and servitization. This provides insights into how the skills mix and demand for labour might change across value chain segments and geographies. With input from industry experts, academics who specialize in production industry topics and labour leaders, we assigned the potential magnitude of the impact these trends might have in specific geographies and value chain segments.

What is a scenario and how are they modelled?

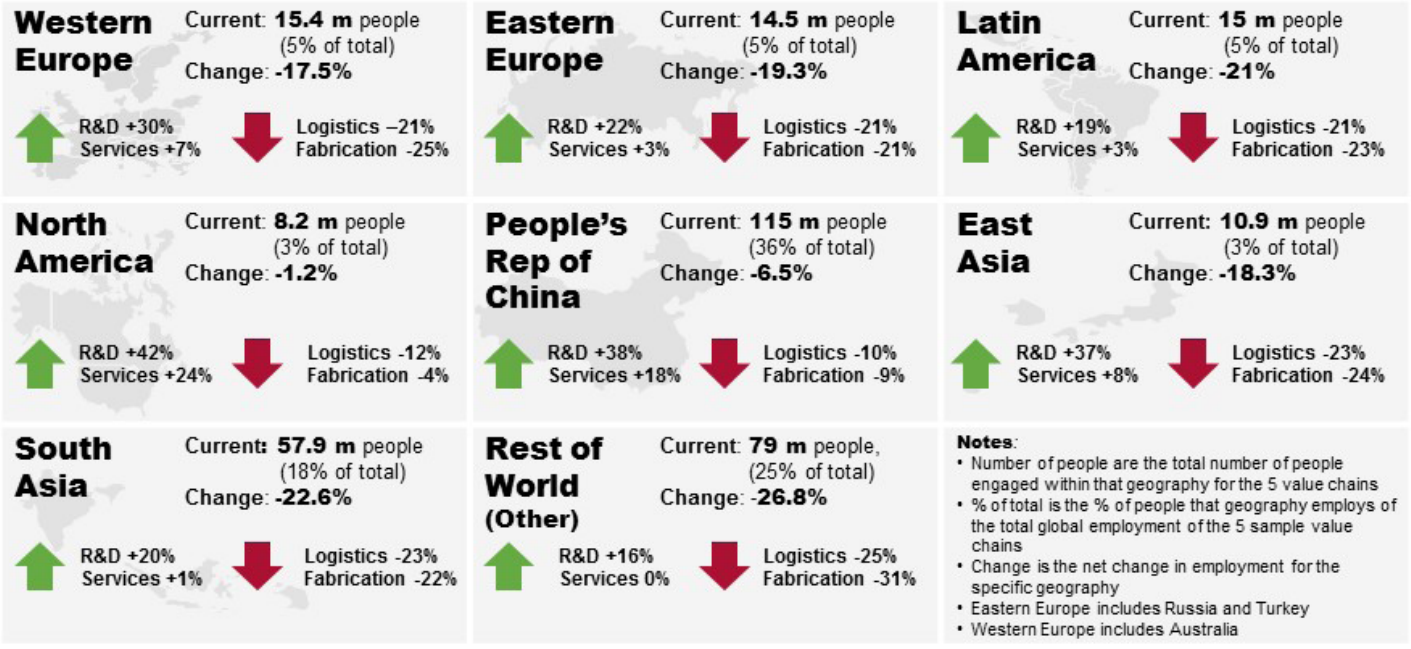
The scenarios generated from the model are the combined effects of five trends – automation, localization, customization, protectionism and servitization.

1. Identify magnitude of impact for each trend by value chain segment, geography, and industry
2. Simulate the "before" and "after" of each trend individually
3. Combine the individual trend impacts and remove duplication effects across trends to get the industry-specific scenario

By estimating the amount of value added in US$ that will be generated by these trends in each value chain segment and geography, we are able to estimate the number of workers that might be needed in each segment, geography and skill group.[17]

[17] Expanded detail can be found in Appendix 1: Technical Model Overview. To find out more about the data that underpins the model, please reach out to the System Initiative on Shaping the Future of Production team.

Figure 13: The geography of production tomorrow



Key findings:

- The biggest changes in value chains will occur in non-core production steps, such as R&D, design, logistics and direct input materials.
- At highest risk for skills mismatches are East Asia, Western Europe, North America and the People's Republic of China.
- The regions with the highest risks of worker displacement due to automation are South Asia and other developing economies. The greatest impact would be on middle-skill edworkers.

As the Fourth Industrial Revolution develops, companies will change the way they operate and the traditional functional and physical boundaries between value-chain segments will blur. Based on the scenarios, the new drivers of change across global value chains are expected to be the rising demand for customized products and increasing rate of servitization, which is the reliance on service revenue by production-industry companies.

Automation will continue to displace workers around the world and other advanced technologies will affect the type of labour and skills that companies will need. Increasingly, these technology-led changes will take place outside the factory and affect labour and skills demand in other parts of the value chain. At the same time, technology is changing the ways in which companies source, manage and retain their workforces.

Companies are creating new ecosystems of talent through the virtualization of work. Different types of workers will be affected in different ways, and the impacts will vary by geography and industry. Shifting value chains, new operating models and rising consumption in developing economies will move demand for workers of varying skill levels to different places around the globe. As a result, the importance of building a highly skilled production workforce is increasing, as is the impact that services has on the end-to-end production value chain.

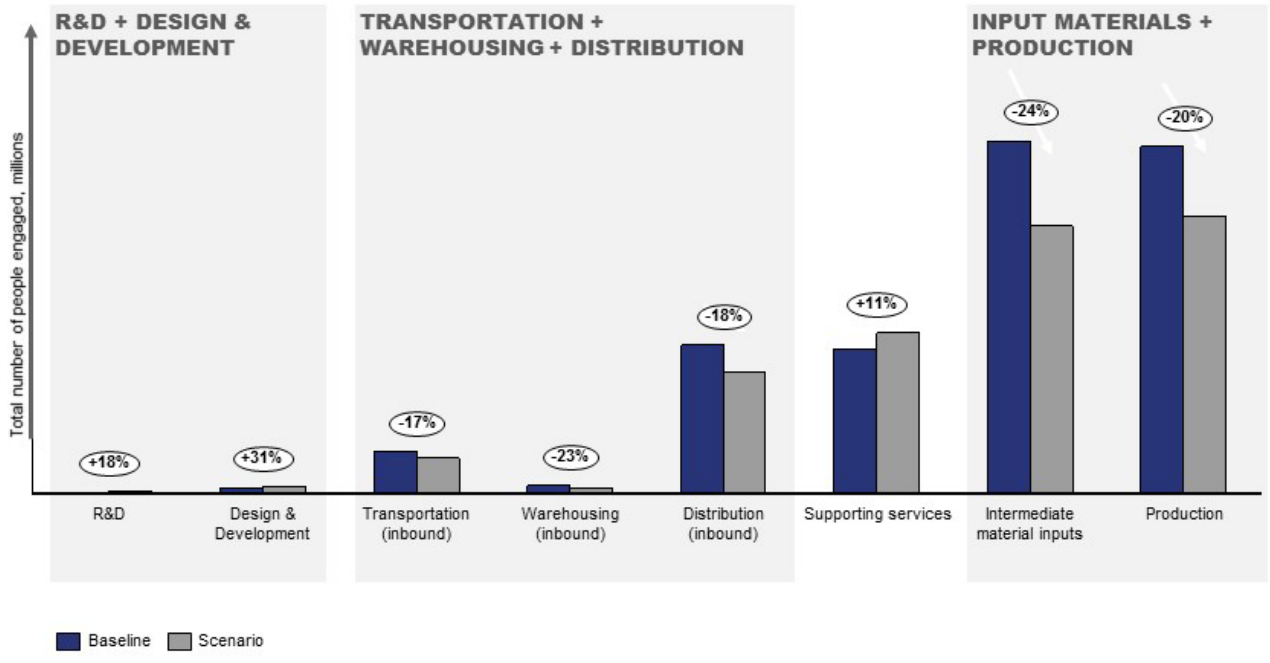
Value chain shifts

Changes in value chains, including consolidation of supply chain segments, will be a major factor in determining labour demand. R&D and design, which are critical pre-production steps, will start to merge because of technology. Additionally, the trend that has been ongoing over recent decades – the merging of transportation, warehousing, and distribution segments into a single value chain segment – are expected to continue, creating its own ecosystem of jobs and skills.

New technologies are influencing R&D activities and advancing the design of products. This means traditional finished goods manufacturers will start to pick up some activities currently being done by first-tier, and in some cases second-tier, suppliers.

New product design and development processes. Traditional design tools, which were considered essential to the design and development of a product are being replaced with new technologies. For example, computer-aided design (CAD) is being increasingly replaced with advanced design synthesis in the aerospace industry. The technology has existed for a long time, but advancements in this area have led to CAD being used at scale across this industry. This trend also creates a potential mismatch in skills because CAD technicians are considered to be specialists. Advanced design synthesis is starting to merge the traditional functions of a CAD technician, design engineer and process engineer into a single function.

Figure 14: Consolidating value chain segments



CAD and Advanced Design Synthesis in the Aerospace Industry, and what it means

Although designers use CAD (computer-aided design), many design decisions and unique characteristics are made by individual designers.

Advanced design synthesis provides designers with a platform to not only create a design (what CAD does), but also simulate and understand additional elements to inform and standardize the design like feasibility, cost, and factory capability (Queen, 2017). Where many of the decisions and design features used to be in the hands of the designer or CAD technician, this technology can provide options for the designer and in some cases, make these decisions for the designer.

Workforces across all industries will be affected by the convergence of these two value chain segments – some more than others. In the five industry value chains, textiles will likely be the least impacted by this convergence, while the more knowledge-intensive industries such as automotive and electronics will be affected the most. While this convergence will cause a fundamental change in the profile of workers within this value chain segment, it does not necessarily mean that job displacement will follow. Scenarios indicate that the higher-skilled value chain segments related to product design and development are the most likely to create jobs.

Logistics. The three logistics value chain segments (transportation, warehousing and distribution) have been consolidating in recent years, a trend that will intensify in the future. Unlike the product design and development value chain segment, however, the logistics segment is at the highest risk of a combination of job disruption and job displacement.

New technologies impact how these once discreet value chain segments – transportation, warehousing and distribution –interact with one another. From a combination of the quantitative findings and engagements with various experts,[18] the logistics segment is the most susceptible to job disruption given the current industry and macro trends. Technologies, such as predictive analytics, enable more efficient fleet route optimization, while real-time data and connectivity platforms provide seamless communication and linkages between these three segments of the value chain. The need for an overarching platform across the providers in all three of these segments is largely responsible for the consolidation of these three segments.

Technology simplifies this value chain and creates a significant source of value to businesses; however, it will also displace a significant number of workers. Even without automation technologies, such as driverless cars and fully automated warehouses, the largest decrease in demand for labour will occur in this area of the value chain.

Most workers at risk of being displaced are in South Asia and other developing economies, with up to 18% of the overall workforce across this value chain segment impacted. Figure 15 illustrates the expected impact by geography.

[18] See acknowledgements for list of experts and organization that have contributed to the findings in this report.

Figure 15: Logistics value chain segments: South Asia and other developing economies

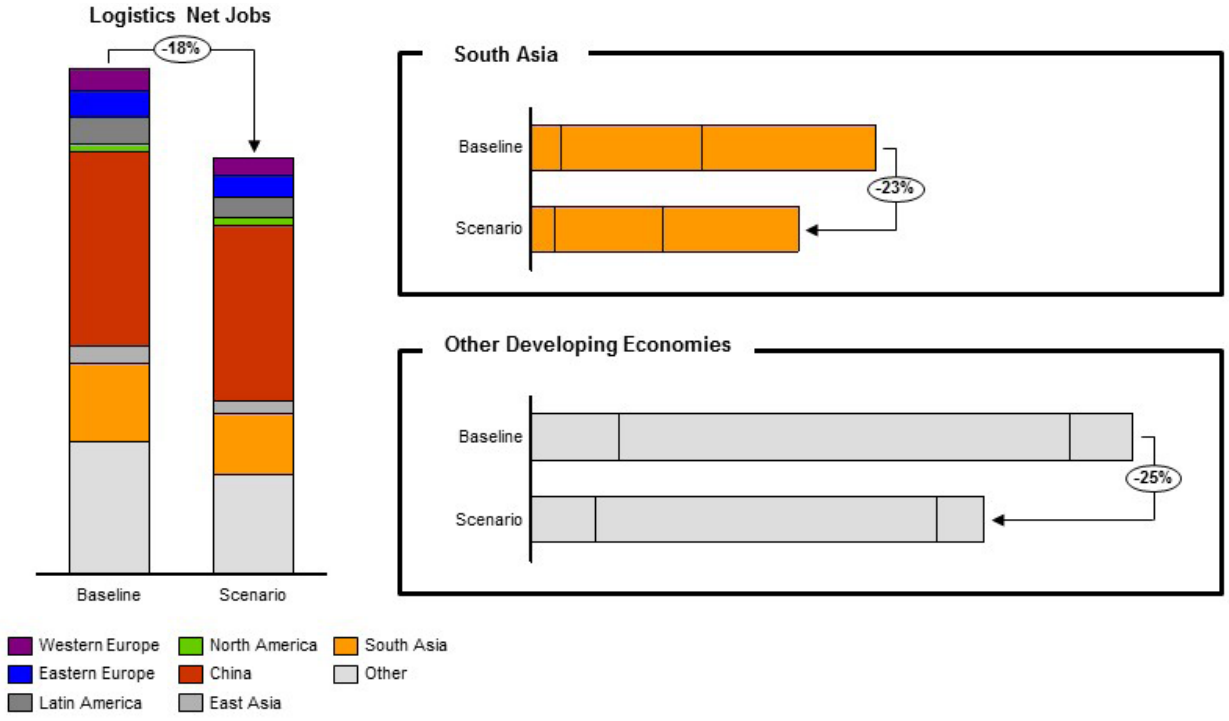


Figure 16: Impact on manufacturing value chain segment

Manufacturing skills mismatch risk		Skill Level		
		High	Medium	Low
Geography	Western Europe	Moderate	Moderate	None
	Eastern Europe + Turkey	Moderate	Moderate	Moderate
	Latin America	None	None	Moderate
	North America	Significant	Significant	Significant
	People's Rep of China	Significant	Significant	Significant
	East Asia	Moderate	Moderate	Moderate
	South Asia	Moderate	Moderate	Moderate
	Other	None	None	None

Simplifying manufacturing processes. The trend is to design products with fewer parts and that require less complex assembly processes. Simplified design and manufacturing requires a less complex supply chain. With fewer inputs, there may be a need for fewer suppliers and potentially manufacturers will make more of their own parts.

The simplified manufacturing process also implicates the need for less labour, but there are more factors at work that will determine labour demand in manufacturing. There will likely be an overall reduction in the demand for workers in global manufacturing due to automation, not to simplification of the process. After automation, the next largest trend determining manufacturing labour demand will be rising consumer demand for customized products, which will require additional high-skill talent. Figure 16 shows the amount of impact across geographies and associated skill levels in the manufacturing value chain segment.

Despite job creation in some geographies and value chain segments, skill mismatches could hinder employment

Work shifts will occur within the value chain, but production footprints are expected to shift globally, mirroring large consumer demand. Mismatch risks would likely be highest in two regions: Geographies with a generally high-skilled workforce and a relatively small production workforce; and those that have a high concentration of demand in their domestic markets.

High-skilled but small production workforces could be unable to meet future production skills demands

Customization and servitization will be leading drivers of job creation. The impact of these developments will be felt most in product design and development, as well as support services. While demand will increase for high-skilled labour, most of the work will not shift to new locations. This could lead to skill mismatches because the places where the high-skilled work will increase the most also tend to be places that have small production labour forces. Where companies have offshored work and reduced local production employment, demand for production labour is now rising beyond what labour markets can currently supply.

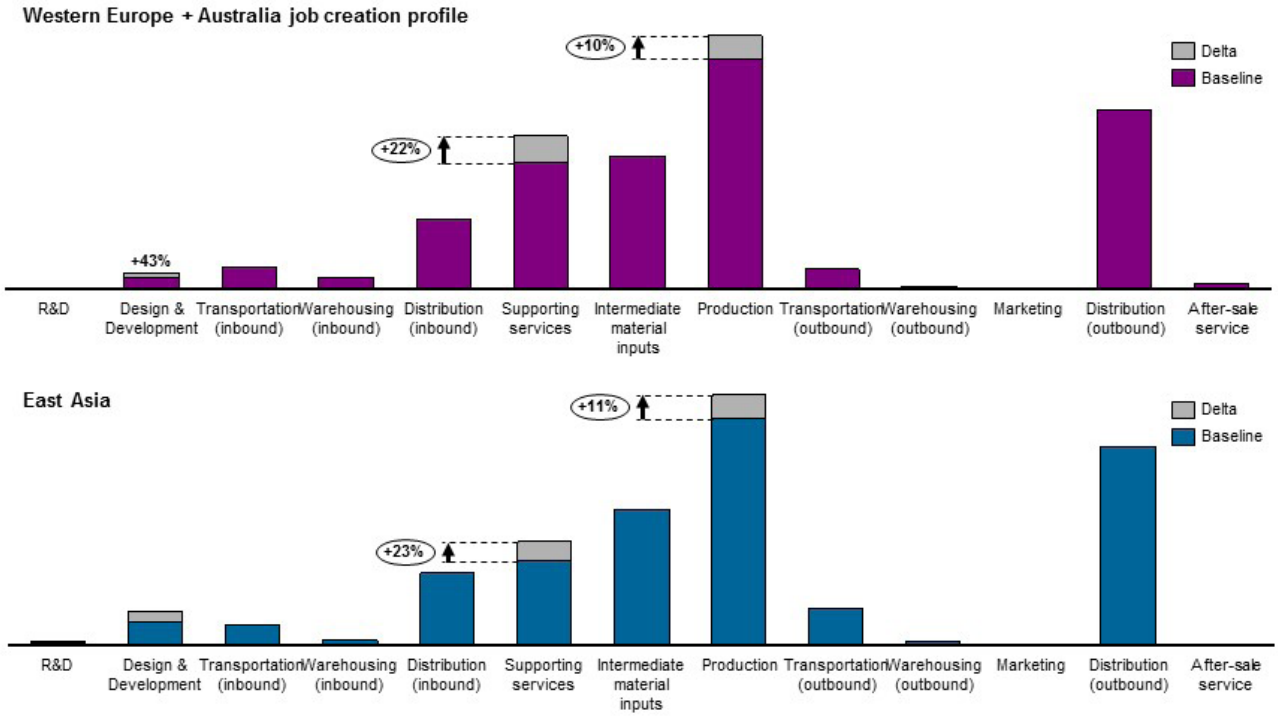
This trend is most significant in Western Europe, Australia and East Asia. Customization and servitization could sharply increase demand for high-skilled labour, particularly in the product design and development value chain segments, but also in support services and manufacturing.

Western Europe. Although Western Europe remains a manufacturing powerhouse, with a concentration of work in high-value segments such as design, the production workforce has contracted as work has been offshored to lower-cost labour markets in developing economies. Only about 5% of the workforce for the five industry value chains is employed in Western Europe and Australia. Nearly one- quarter of this workforce is engaged in high-skill jobs. However, higher demand for customized products and growth in servitization could raise demand for labour in some value chain segments by up to 25% above current levels, which could lead to skill gaps.

Figure 17 illustrates Western Europe's current skills profile and the relative impacts expected, based on increases in demand for customized products and servitization.

East Asia. The biggest risk for skills mismatches in this region will be in product design and development. Primarily because of customization and servitization, the demand for product design and development skills could increase by up to 45% above current levels. This dramatic increase in demand for higher-skill production workers could pose challenges in East Asia, where the production labour force is relatively small.

Figure 17: Western Europe, Australia and East Asia: Potential areas of skills shortages



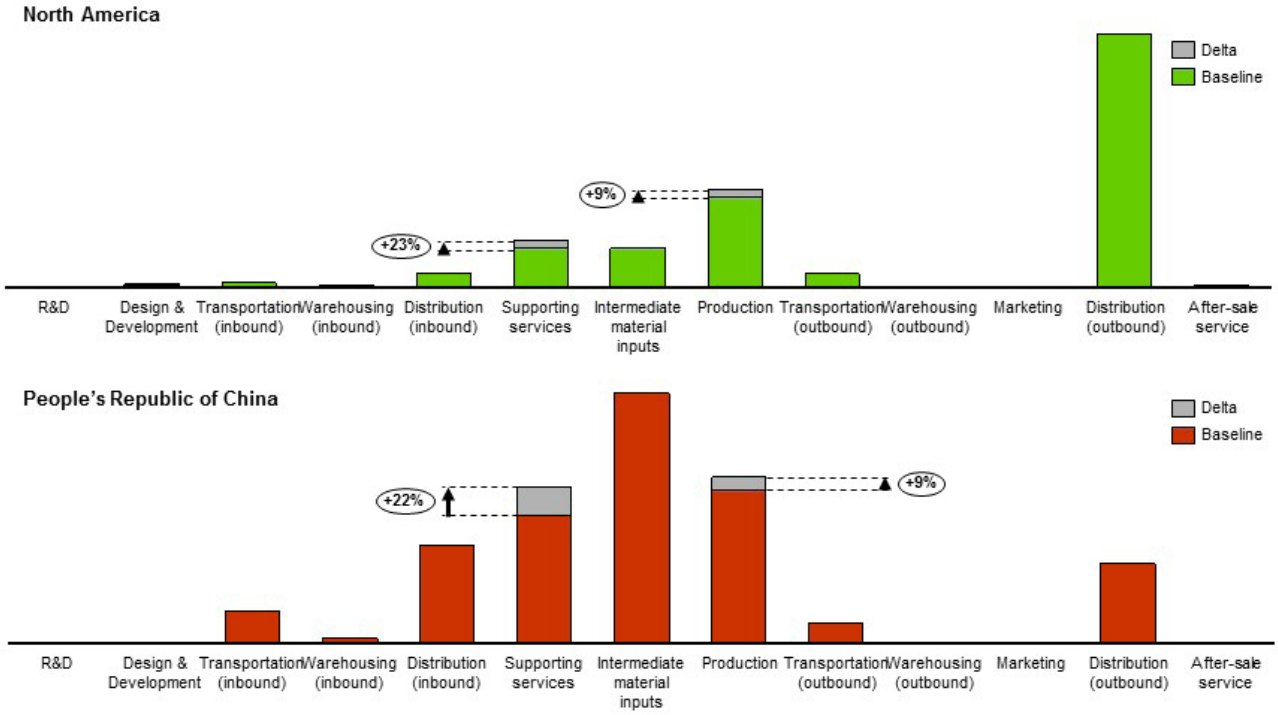
Market growth could lead to skill shortages

Skills mismatches could be greatest in the largest consuming economies. Many macro and industry trends point to production moving closer to the consumer. The two largest demand economies analysed are North America and the People's Republic of China. For these regions, job creation could occur across all segments of the value chain because of market growth, but the fastest job growth is expected to be in segments that require higher skills, such as design and development and services. This job growth could be impacted by automation.

North America. North America has a significant risk of skills mismatch because it is one of the largest consuming markets, but has the smallest production workforce in the five industry value chains analysed. Scenarios predict that North America will see job growth in some high-skilled value chain segments despite automation.

North America has a relatively highly skilled workforce. Even so, there is a risk of a skills shortage at all skills levels, including low-skill labour. Because only 6% of production workers are in low-skill jobs across the five industry value chains, the challenge in North America could be shortages related to low-skill work across all value-chain segments in production industries.

Figure 18: North America and the People's Republic of China: Potential areas of skills shortages



The People's Republic of China. With massive demand within the country, the People's Republic of China could be at risk for skills mismatches, despite its large production industry labour force. More than half of the People's Republic of China's production labour force is employed in low-skill work today, and less than 10% are in high-skill work. As part of the Made in China 2025 initiative, the People's Republic of China is making a concerted effort to move into more value-added work across production value chains. This could lead to significant skills mismatches, particularly in the more knowledge-intensive segments of the value chain, such as product design and development, as well as support services.

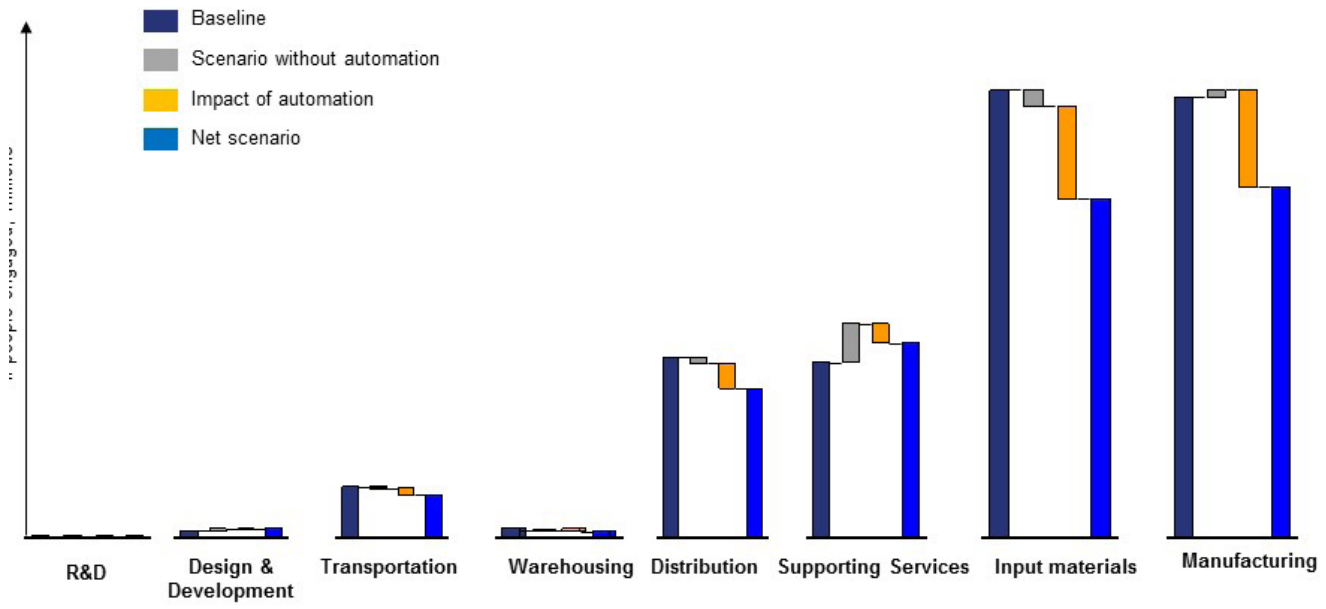
Automation: A challenge on two fronts

Automation is the largest driver of job displacement and job disruption. Once automation is taken into account across all value chain segments, there will be very different impacts on labour demand across the value chain and across geographies. Automation creates a challenge to which no geography or type of worker is immune.

The geographic clusters where workers are most vulnerable to displacement from automation are South Asia and 'Other' developing economies. An estimated 23% of production workers in South Asia could be at risk and 27% in other developing economies. Most of this displacement will be felt among middle-skill workers.

The regions where middle-skill workers are most likely to be affected are those that have tried to move from low-skill to medium-skill labour to increase their economic competitiveness. These countries may need to change their human capital strategies to address the increasing polarization of skills demand. Experts believe this indicates a need for significant reskilling and upskilling.

Figure 19: Future value chain scenarios with and without automation



A call for action: Building the right workforce capabilities in the right locations

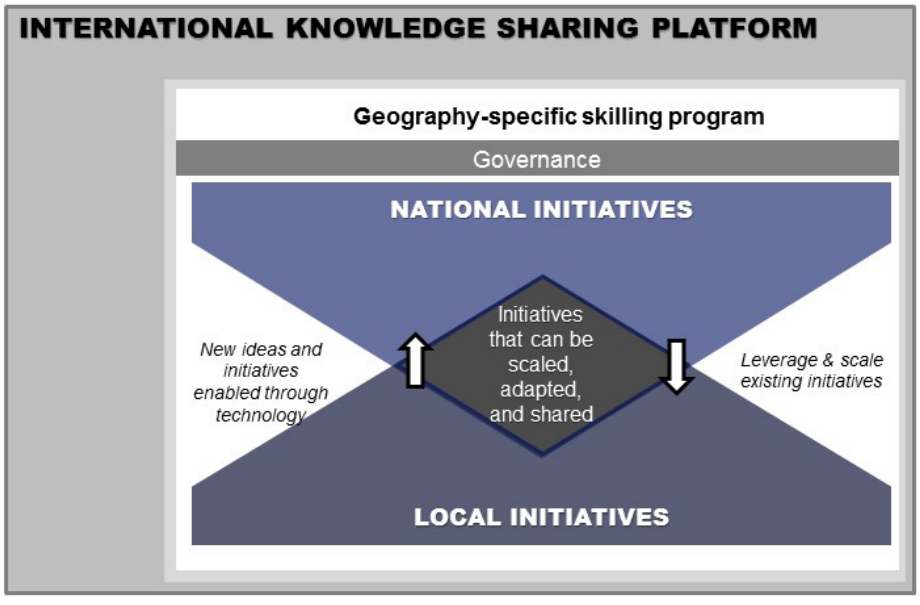
The research findings show that the industry and macro forces at work in production industries will play out in different ways in different parts of the world. This means the skills training initiatives will need to be tailored to specific countries and regions, based on the mix of local industries and the skills currently available in local labour markets. Each geography will need its own human capital and skills strategy.

At the same time, all countries will need to develop new approaches to skills training because traditional approaches are insufficient. Around the world, tens of millions of workers will need to acquire new skills and they will need to do so quickly. To accomplish this, countries need to build multistakeholder sponsorship and governance. They will also need mechanisms to foster dialogue among key constituents and share knowledge and best practices, both within countries and across borders.

Global Initiatives (Top-Down Initiatives): Top-down initiatives should be created by multi-stakeholder partnerships and sponsored by leaders who sit on the governance boards. They should be focused on driving large-scale initiatives owned by at least two constituent groups (e.g. employers and unions). These initiatives should be tracked and measured through regular checkpoints by the governing body.

Local Initiatives (Bottom-Up Initiatives): Bottom-up initiatives—within a province or city or industry cluster—should be encouraged within countries and regions. These initiatives do not require sponsorship by the governing body, but they should be aligned with the overarching human capital strategy. Bottom-up initiatives should be allowed to grow organically and the governing body should look for ideas that might be adapted or inclusion top-down initiatives.

Figure 20: Future value chain scenarios with and without automation



A model for multistakeholder programme management and knowledge sharing

The framework illustrated below (Figure 20) depicts a recommended model for using a multistakeholder approach to carrying out human capital strategies for production industries and managing upskilling and reskilling initiatives. This model enables governance by multiple constituents, including government, employers and unions, and encourages institutionalized dialogue among these players. The model includes a platform for sharing knowledge and best practices, both within a particular region or country and internationally.

Establish a human capital strategy

Countries require a human capital strategy for the digital age. We recommend a strategy comprised of three priority action areas, underpinned by a set of enablers that requires multi-stakeholder collaboration.

Solutions should fall into three priority action areas:

- **Create an adaptive workforce.** Create an adaptive and highly responsive workforce by embedding agility in the organisational structure, skills, and mindset of the workforce itself
- **Plan for an uncertain future.** Use advanced analytics to generate insights that inform decision-making and provide the lead time to address employment and skill shifts before they materialise
- **Up-skill and reinvigorate the workforce.** Encourage a "continuous learning" mindset by upskilling the existing workforce. Build digital capabilities by taking a long-term approach to growing the talent pools for the future.

For solutions within any of the three priority action areas to be effective, they must be underpinned by a set of enablers, including education systems which are future-proofed, a clear sense of shared social responsibility for private and public sectors alike, and a forward-looking policy framework.

Table 2: Priority Matrix by Geography

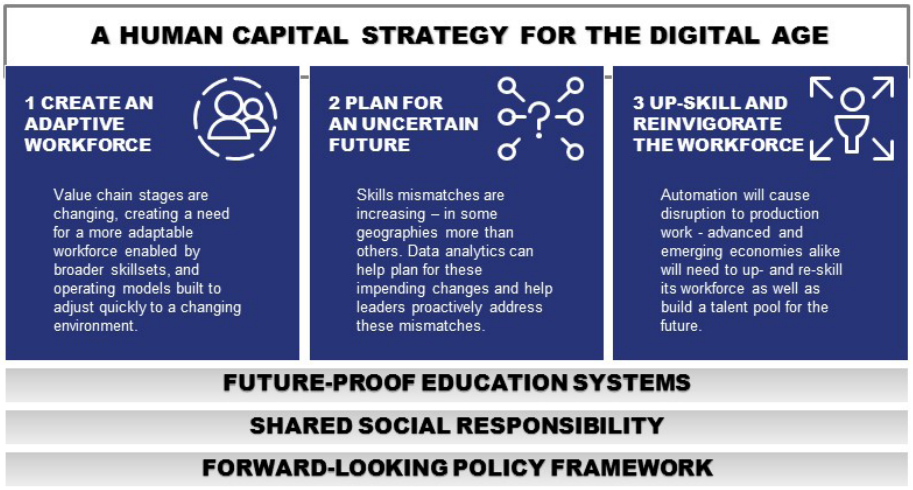
Geography	Key Drivers		
	Value chain shifts	Skills shortages	Automation
Western Europe	3	1	2
Eastern Europe and Turkey	2	3	1
Latin America	2	3	1
North America	2	1	3
People's Republic of China	3	1	2
East Asia	2	1	3
South Asia	2	3	1
Other	2	3	1

1=high priority, 2=medium priority, 3=low priority

To set the proper priorities, the following matrix is recommended to rank the three key drivers of employment and skills demand.

- **Value chain shifts.** The degree of susceptibility to widespread skills changes across value chain segments.
- **Skills shortages.** The degree of susceptibility to skills shortages.
- **Automation.** The degree of susceptibility to job displacement through automation.

Figure 21: A Human Capital Strategy for the Digital Age



For more insights on drivers that should be considered in a human capital strategy, see the World Economic Forum's report: Country Readiness for the Future of Production Insight Report, published as part of the System Initiative on Shaping the Future of Production.

Employ digital tools

Thoughtful use of digital technologies can help to improve the performance of skills programmes at every stage. Big data analytics can help pinpoint skill gaps and project future labour demand. Computer-based teaching systems can track student progress and customize lessons for individual workers. Virtual-reality technology can demonstrate the proper way to carry out new tasks and give an employee a safe environment in which to practice. Digital platforms can help administer programmes and connect workers and employers with training resources.

Adopt an appropriate governance framework

To ensure that top-down or bottom-up initiatives remain aligned with the human capital strategy they must be managed with a flexible framework that allows for rapid adjustment. Leaders should always be looking for opportunities to scale up existing initiatives and from pockets of excellence. To get to the best solutions in the shortest time, countries can use the agile approaches that are spreading across business.

Teams should be taught design thinking to devise programmes that address customer and worker needs and use experimentation, testing, and even fast failing to refine their offerings. During implementation, pilots can help refine what works before a large-scale rollout. It is critical to use these iterative approaches before launching initiatives, rather than aiming for perfection. Taking the time to go back to the drawing board, iterate and test will create solutions that work better and, faster.

Finally, a flexible governance framework is critical to meeting the objectives of the programme. The governance structure should create ownership and accountability for constituents by giving them the authority to direct investment decisions and inform policies. The governance framework should also establish the rules for shaping policies, guiding investment decisions and fostering knowledge sharing.

Share knowledge across borders

The World Economic Forum is uniquely positioned to act as a knowledge-sharing platform. The Forum has a wide range of resources, some of which can be found in the Future of Education, Gender, and Work system. To learn more about the World Economic Forum System Initiative on Shaping the Future of Education, Gender, and Work and the associated projects, please refer to the website: https://www.weforum.org/system-initiatives/shaping-the-future-of-education-gender-and-work.

Next steps

The research has shown how industry and macro forces are reshaping labour demand in production industries. Scenario modelling has provided a map of where these forces will likely have the greatest impact. The next step is to focus on defining the appropriate response in each country and region. The key focus should be to agree on a multistakeholder framework and collaborative platform to develop geography-specific strategies and to identify initial top-down and bottom-up initiatives to pilot in the coming year. Data analytics should be used to find the areas of greatest need and to help prioritize initiatives.

It is critical to facilitate institutionalized multistakeholder dialogues to prepare the labour force for the evolving needs of production industries. Business leaders and policymakers need to take joint responsibility to create these dialogues and to ensure they are organized and funded for success.

Appendix 1: Technical model overview

The purpose of the model is to quantify the current geography and dispersion of employment and skills across five globally important production industries. This approach, which is rooted in Global Value Chain analysis, delivers a coherent framework to assess the potential impacts of several important economic and geopolitical developments on the evolution of employment and its skill mix. The construction of the model can be broken down into two steps:

1. Establish the baseline of the current global geography and dispersion of production employment and skills.
2. Simulate the potential impacts of various relevant scenarios across the global value chain

Step 1: Establish the baseline[19]

The baseline methodology uses well-established research identifying value chains while accommodating the constraints related to data availability.

Industry selection

The scope of the production sector is very broad, particularly when expanded end-to-end along the global value chain where it encompasses a vast array of companies, workers, activities and input industries. To focus on the essentials, the scope for this phase of the project has been narrowed down to five industries – automotive, textile and apparel, electronics, chemicals and industrial equipment. These industries were selected because they provide a representative sample of the different types of sub-sectors that lie within "production". However, they are also sufficiently important to capture the scenarios that are likely to impact an estimated 80% of the industry with similar effect.

The FMCG (fast moving consumer goods) or heavily retail-oriented sectors were not chosen due to the multiple product channels across these industries that might show notably divergent impacts. Extending our model to these sectors remains on the research agenda.

Global value chain definition

The structure of the model is based on the concept of global value chains (GVCs), which describes the full range of value adding activities required to bring a product from conception through the various stages of production, to its end use for the customer and beyond. The GVC has been broken into eight steps, and then further grouped into stages, based on whether the step takes place prior to the manufacture of the end-product (the pre-fabrication stage), the manufacturing of the product itself (fabrication stage), or the downstream activities related to the sales and distribution of the product to the end customer.

The value chain stages used in the analysis are broken down below. The pre-fabrication and fabrication stages are considered the global part of the value chain, as these are the stages that have a significant amount of cross-geography movement and interaction. The post-fabrication

[19] Based on studies on references: (Frederick, 2014); (Timmer, Erumban, Los, & Robert Stehrer, 2014); (Wang, Wei, & Zhu, 2013); (Timmer, Dietzenbacher, Los, Stehrer, & Vries, 2014); (YE, Meng, & Wei, 2015)

Table 3: Industry description

Industry	Description	Position in Value Chain	Type of Industry	Other similar industries
Automotive	Motor vehicles	Downstream	B2C (business to consumer)	Aerospace
Textiles and apparel	Apparel and the textiles used to make apparel	Downstream	B2C	Luxury goods
Consumer electronics	Physical personal electronics (mostly hardware and the software that goes into physical hardware)	Downstream	B2C	
Chemicals	All chemicals	Upstream	B2B (business to business)	Beverage (plus other continuous process industries)
Industrial equipment	Industrial machinery used in factories and other industrial uses	Intermediary	B2B	Aerospace

stage of the value chain is considered the local part of the value chain, in that the downstream sales, distribution and other customer-related activities in production industries take place in the domestic market where the consumer is physically located.

– **Pre-fabrication value chain stage.** This stage includes all activities relating to the value chain steps that include R&D; design and development (of the process); inbound logistics including transportation, warehousing and distribution of all inbound products used in the manufacturing process; support services and the physical input materials used in the manufacturing process, for example metal that goes into the manufacture of cars or electronic components that go into industrial equipment)
– **Fabrication value chain stage.** This stage includes all core manufacturing activities that go into the fabrication of the end product, for example all manufacturing activities conducted by OEM (original equipment manufacturer) car producers.
– **Post-fabrication value chain stage.** This stage includes all activities relating to post-fabrication of the final consumer product, which includes outbound transportation, warehousing, distribution, marketing, and after sales services.

Employment and skill level

The structure of employment in GVCs is characterized by sector of employment, educational attainment and skill level.

Table 4: Skill level, educational attainment and typical tasks performed

Broad skill level	Educational attainment	Typical tasks	Categories of occupation
High	Tertiary education	Complex technical and practical tasks; interpersonal communication; tasks that require problem-solving, decision-making and creativity; analysis and research, etc.	Manufacturing Executive Manufacturing Technician R&D Manager R&D Scientist Service Manager
Medium	Lower and upper secondary level of education and post-secondary, non-tertiary education	Operating machinery and equipment; maintenance and repair, manipulation of information; simple calculations and written records of work completed, etc.	Manufacturing Specialist Manufacturing Supervisor Salespersons Support Service Clerks Customer Service Representative
Low	Primary or lower secondary level of education	Simple and routine physical or manual tasks, etc.	Manufacturing Operator Driver Picker & Packer Low-skilled Support Service Clerks

Source: Accenture on SOC, ISCO and ISCED

Model structure

The model constructed is aimed to quantify the employment and skills distribution (high, medium and low skills levels) across geographies and the global value chain. It takes advantage of existing international input-output measures to capture the degree and position of different countries' participation in GVCs.

Constructing the global and local value chains in terms of value added (in US dollars)

The value of the final product was decomposed into the contributions from various types of suppliers along the production timeline based on the defined GVC. In parallel the suppliers' geographic origin was traced, which allocates the appropriate value added (in terms of US dollars) to the associated geography.

As a result, the value added of a final product (passenger vehicles, for example) can be decomposed into a global value chain. This shows the value from all industries and countries contributing into the final product. Through the backward linkages a map of value flow by value chain segment and by geography is created.

The global view was constructed using the methodology defined above for the pre-fabrication and fabrication stages. To capture the post-fabrication stages, a domestic market approach must be taken because the structure of the downstream activities is heavily market-specific. The value-added from transportation, warehousing, distribution,

marketing and after-sale service in the post-fabrication stages is called the markup (or margin) and it is specific to each market. A key assumption is that there is no difference in markup rate across all products in the individual country market.

Allocating employees engaged

By using the number of workers employed by country and by industry and by skill level (high, medium or low), the map of value added was overlaid with employment and workers were distributed proportionally according to their individual productivity levels. This creates an employment map by value chain segment, by geographic region and by skill level. To estimate impact of automation the allocation of working time was considered by each category of employees (by value chain segment, region and skill level) into human-like tasks (which are less likely to be automated) and machine-like tasks (which are more susceptible to automation).

Step 2: Create scenarios

The next step in the research was to define the most important current economic and geopolitical trends with the potential to significantly change the landscape of production and assess the likely employment effects across production GVCs.

Scenario simulation tool

A series of trends that could affect production industries and the global economy were identified and tested with expert groups. As a result, five of them (automation, customization, growth of services, localization and protectionism) were incorporated into the scenario simulation based on the baseline framework.

A tool was created to simulate the combinatorial impact of all five trends as well as the impact of each separately, keeping everything else constant, to identify the specific one-off effects on employment in terms of direction of change, geographies affected and skills redistribution. For each sample value chain and associated end markets, a unique combination of trends was applied depending on industry and geography specifics.

Validation approach

To validate the set of assumptions that generated each of the scenarios, the team held a series of interviews with experts to test the methodological approach for both the baselines and scenarios. Additionally, some interviews were used to identify the estimated magnitude of impact each of the trends might have on different geographies and industries. These interviews helped to refine the model methodology and trends. The interviews also informed the assumptions around impact (high, medium or low) they might have on the industries and geographies.

Finally, a series of workshops were held with community members of the World Economic Forum to refine trends and discuss the insights from the scenario simulation and possible implications for future actions.

Appendix 2 Breakdown of geographic clusters included in the model

Geographic clusters have been identified by grouping countries that share similar production characteristics and workforce profiles. A detailed breakdown can be seen in the below matrix.

Western Europe and Australia	Eastern Europe and Turkey	Latin America	North America
Australia	Bulgaria	Brazil	Canada
Austria	Cyprus	Mexico	United States
Belgium	Czech Republic		
Switzerland	Estonia		
Germany	Croatia		
Denmark	Hungary		
Spain	Lithuania		
Finland	Latvia		
France	Malta		
United Kingdom	Poland		
Greece	Romania		
Ireland	Russian Federation		
Italy	Slovakia		
Luxembourg	Slovenia		
Netherlands	Turkey		
Norway			
Portugal			
Sweden			
People's Republic of China	**East Asia**	**South Asia**	**Other**
People's Republic of China	Japan	Indonesia	Rest of the world
	Republic of Korea	India	

Appendix 3: Baseline data by industry, geography and value chain segment

Table 5. The automotive global value chain at a glance: 67.5 million workers engaged, $2.2 trillion valued added

Number of workers engaged (thousands)	Value chain segment					
Geography	R&D	Design and development	Inbound logistics	Supporting services	Intermediate material inputs	Production
Western Europe	11.0	105.9	193.2	111.5	735.7	1,071.6
Eastern Europe	2.7	25.7	226.7	42.1	812.0	508.9
Latin America	40.7	43.7	195.3	78.1	1,024.7	723.8
North America	15.2	37.8	95.2	40.0	271.9	677.7
People's Republic of China	27.6	64.0	1,398.6	246.1	4,508.7	5,737.2
East Asia	11.5	161.0	142.7	31.1	478.1	499.3
South Asia	-	61.5	480.7	30.1	1,800.4	981.4
Other developing economies	51.5	112.9	855.4	252.4	3,202.7	2,320.8

Table 6. Apparel and textile global value chain at a glance: 123.4 million workers engaged and $1.2 trillion value added

Number of workers engaged, thousands	Value chain segment					
Geography	R&D	Design and development	Inbound logistics	Supporting services	Intermediate material inputs	Production
Western Europe	1.8	33.5	74.0	37.2	228.2	339.3
Eastern Europe	0.4	16.0	135.9	21.9	524.4	254.5
Latin America	13.1	11.9	66.5	17.6	423.4	228.7
North America	3.2	9.2	20.2	9.0	53.1	131.2
People's Republic of China	6.7	17.9	886.0	127.7	3,937.1	2,820.2
East Asia	1.1	17.4	37.4	10.7	152.2	110.6
South Asia	-	71.0	926.5	62.7	3,064.1	2,198.8
Other developing economies	19.0	49.7	749.0	163.1	3,723.6	1,548.5

Table 7. Consumer electronics value chain at a glance: 38 million workers engaged, $1.2 trillion value added

Number of workers engaged, thousands	Value chain segment					
Geography	R&D	Design and development	Inbound logistics	Supporting services	Intermediate material inputs	Production
Western Europe	5.8	34.3	58.9	32.1	184.2	361.5
Eastern Europe	0.9	6.4	77.0	13.4	255.8	174.2
Latin America	12.5	12.5	42.4	15.6	232.7	242.1
North America	6.8	15.1	23.1	9.8	65.0	205.9
People's Republic of China	35.2	39.0	835.2	105.3	3,206.0	3,765.6
East Asia	15.3	90.2	85.1	24.8	378.8	391.6
South Asia	-	21.8	119.4	8.9	565.0	432.1
Other developing economies	48.5	67.0	402.3	94.5	1,832.2	1,443.1

Table 8. Chemicals value chain at a glance: 14 million workers engaged, $559 billion value added

Number of workers engaged, thousands	Value chain segment					
Geography	R&D	Design and development	Inbound logistics	Supporting services	Intermediate material Inputs	Production
Western Europe	1.3	19.3	52.3	26.0	115.2	240.2
Eastern Europe	0.4	1.5	80.9	14.2	229.0	184.7
Latin America	10.0	12.3	76.3	21.6	320.9	242.7
North America	6.5	14.4	34.1	11.9	84.0	278.0
People's Republic of China	1.6	4.1	136.3	15.9	323.0	430.0
East Asia	1.5	17.3	21.6	4.6	48.3	72.8
South Asia	-	10.8	139.2	7.9	399.4	244.8
Other developing economies	10.4	27.0	268.0	58.2	730.4	714.2

Table 9. Industrial Equipment Value Chain at a glance: 72.5 million workers engaged, US$2.2 trillion value added

Number of workers engaged, thousands	Value chain segment					
Geography	R&D	Design and development	Inbound logistics	Supporting services	Intermediate material inputs	Production
Western Europe	7.8	96.5	165.0	92.0	474.5	981.0
Eastern Europe	1.6	18.5	195.7	34.0	578.7	448.7
Latin America	14.4	28.2	91.4	30.1	483.8	384.6
North America	10.9	27.8	64.7	24.9	164.1	423.0
People's Republic of China	38.4	66.1	1,960.7	245.0	4,837.6	7,767.1
East Asia	10.9	140.0	133.2	33.3	466.0	540.3
South Asia	-	61.8	369.3	20.2	1,178.0	942.3
Other developing economies	43.8	83.1	776.7	178.8	2,328.2	2,412.5

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