pwc

GMIS | Global Manufacturing & Industrialisation Summit

In this report

2 *A macroeconomic snapshot*

6 *The evolution of Canadian manufacturing*

10 *The leap forward*

The Future of Manufacturing - Canada

Foreword

The fundamentals of the Canadian economy are strong with a highly skilled workforce, strong business networks and robust domestic demand. Despite uncertainty around trade (in particular the status of NAFTA) and the energy market that will remain a concern for export competitiveness in the short-to-medium term, the outlook for the Canadian economy is generally positive. In terms of the manufacturing sector in Canada, there has been a drop in gross value-added and employment since 2010. However, a recovery is expected by 2022. The sectors key strengths include its robust technological capabilities and innovation, as well as established industry hubs for automotive in Ontario and aerospace in Quebec. As the largest manufacturing province in Canada, Ontario's growth has been powered by its strong trading relationship with the United States. Nevertheless, despite its strong growth, the tight labour market remains a concern.

The rapid advancements in technology are disrupting how business is done in the manufacturing sector globally, and Canada, with its highly skilled workforce and openness to new ideas, is poised to take advantage of these trends. The Industrie 2030 Plan by Canadian Manufacturers & Exporters, which is backed by the Canadian government, has a bold agenda and its implementation will require policy innovation and a renewed focus on manufacturing as a contributor to revenue, employment and the business environment. In this report, we have outlined three key themes that have the potential to further strengthen the Canadian manufacturing sector going forward.

A. Championing widespread adoption of Industry 4.0 by SMEs:

Investment in Industry 4.0, especially by SMEs, will help drive industry productivity and innovation

B. Strengthening global leadership of the aerospace sector:

Further enhancement of Montreal's role as a hub for aerospace based on its ability to innovate and diversify

C. Developing the manufacturing workforce of the future:

Proactive action to increase the size and skill level of the Canadian manufacturing workforce to be future-ready

Canada already has strong policies and incentive structures to encourage investment, innovation and upskilling in the manufacturing sector but these must be adapted and refreshed to reflect changes at the global level. The critical success factors in manufacturing are changing rapidly and focus on these key themes will position Canada as one of the major global players in the manufacturing sector going forward.

"Canada's economic progress will continue to depend on its traditional strengths in energy, coupled with its manufacturing and technology sectors. Though manufacturing's role in the economy has declined between 2000 and 2016, and productivity has not kept up, the Industrie 2030 plan can truly reignite Canada's manufacturing and industrial sectors, by adopting the disruptive technologies of the 4th Industrial Revolution. These will require investments in new skills and capabilities such as digitization, data analytics, 3D printing, and other innovative tools and techniques. The traditionally strong family businesses and SMEs in Canada will need to lead the way. The Canadian government can help make the manufacturing sector reclaim its role in the economy by providing support e.g., in the areas of research, education, training, industrial clusters, and international alliances."

Anil Khurana
GMIS Organizing Committee
PwC Partner, US & ME, and Advisor

"With a strong and well-established industrial base, a highly-skilled workforce, and an openness to new ideas and innovation, Canada's manufacturing outlook is marked by positivity, and clear strategic vision for translating optimism into impact."

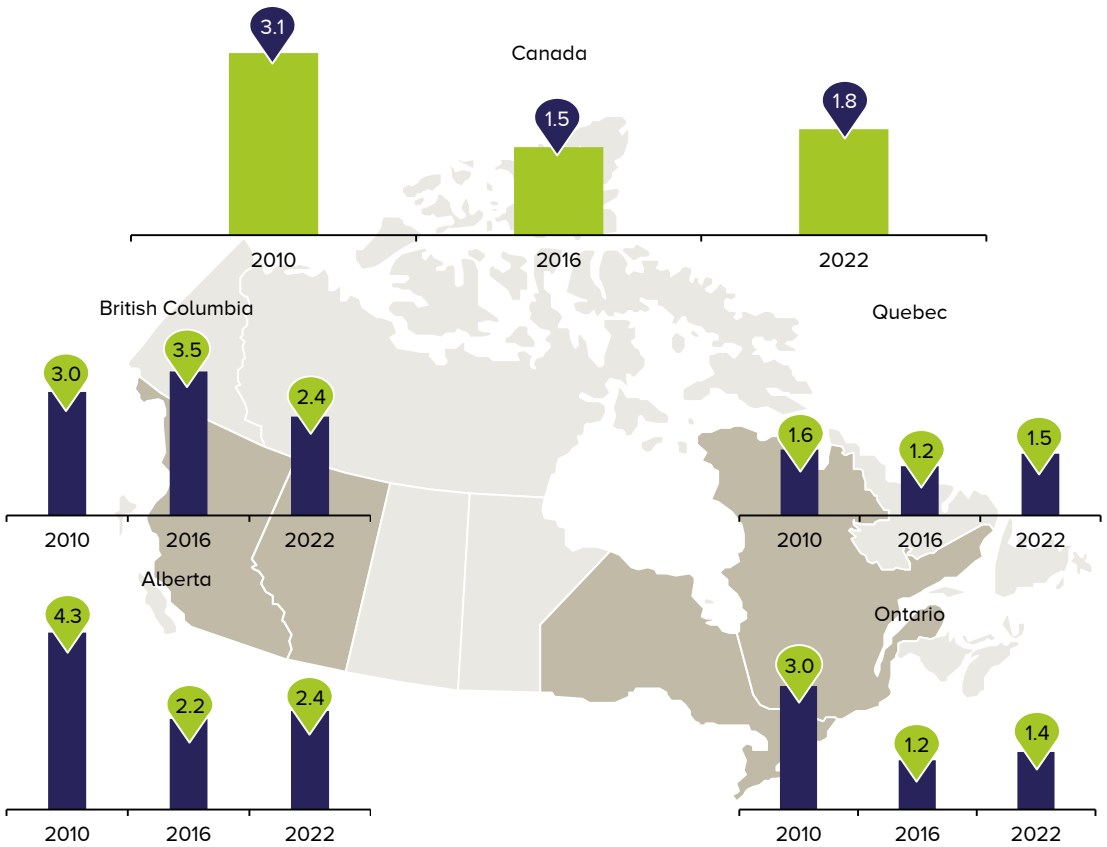
Badr Al-Olama
Head of GMIS Organising Committee,

A macroeconomic snapshot

Canada's economy reached a growth rate of 3.1% in 2017 due to positive trends in the labour market, increasing exports and positive economic development globally. Overall, Canada is in a strong position with a well-educated workforce, low levels of government debt, and a robust business environment[1]. The trend in the labour market is positive, with unemployment reaching a 43-year low of 5.7% in December 2017 and real wages growing at 1%[1], stronger than other major developed economies. Healthy confidence in the business community will be sustained by strong demand growth, consequently expected to drive investments.

However, Canada's economic growth is expected to slow down to 2.3% in 2018 and 1.9% in 2019[1]. The slowdown will be primarily due to lower growth in private consumption (2.2% in 2018 reduced from 3.6% in 2017[1]) and lower government spending. Lower levels of energy production will also reduce overall growth as more sustainable energy production methods proliferate. The biggest risk to the Canadian economy remains potential shifts in trade policy, particularly the renegotiation of the North American Free Trade Agreement (NAFTA).

Real GDP growth, 2010-22 (%)

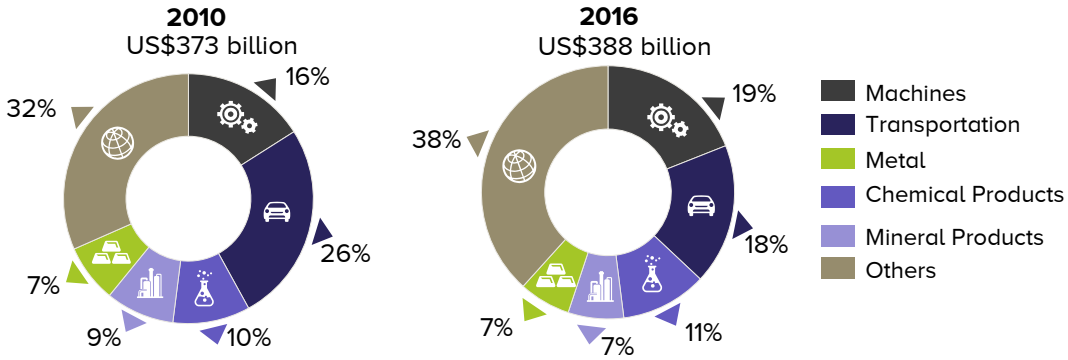


Source: IMF, BMI

Highly developed mixed economy[2], supported by private consumption

- Canada is the 10th largest economy in the world with a GDP of over US$1.5trillion in 2016[1]
- The Canadian model is a mixed economy with a market-oriented economic system. The pattern of production is generally similar to the US
- Private consumption growth peaked in 2017, partially due to the continued increase in employment and real wages, but will likely lower to more sustainable levels moving forward

Key exports from Canada, 2010-16 (%)



Note: Others include vegetable products, precious metals, plastics and rubbers, paper goods etc.
Source: UN Comtrade

Top 5 Export Partners (2016)

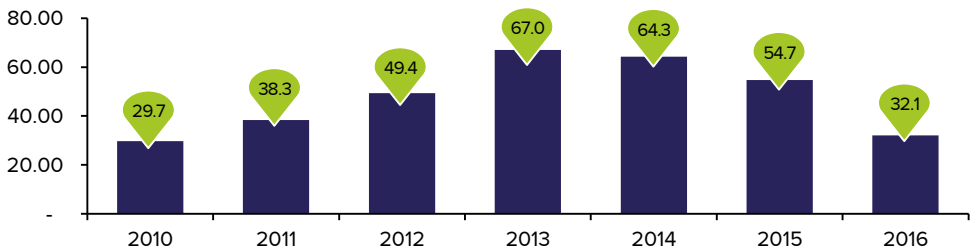
1. USA	(76%)
2. China	(4.1%)
3. UK	(3.3%)
4. Japan	(2.1%)
5. South Korea	(0.86%)

Source: UN Comtrade

Strong export demand with leadership in petroleum exports

- Exports are expected to accelerate to 2.6% in 2018 from 1.8% in 2017[1] driven by a general improvement in the global economy, recovery in oil prices and a positive economic outlook for the US
- Exports of goods and services will account for about one third of GDP over the coming years
- Canada has the world's third largest petroleum and natural gas resources, which accounted for 18% of exports in 2016[1]

FDI inflow into Canada, 2010-16 (US$ billion)



Source: BMI

Top 5 FDI Investors (2016)

1. USA	(47%)
2. Netherlands	(11%)
3. Luxembourg	(7%)
4. Switzerland	(7%)
5. UK	(5%)

Source: Statistic Canada

Attractive investment destination

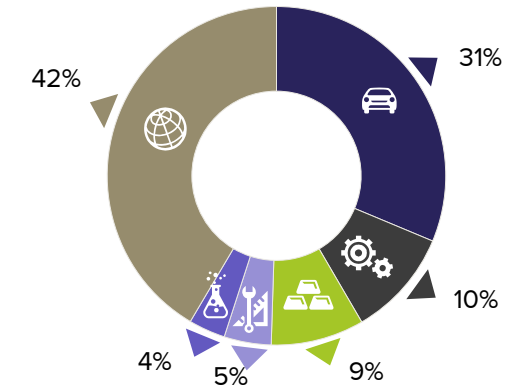
- Canada ranks 13th globally for FDI according to the UNCTAD's 2017 World Investment Report, supported by a favourable business environment (Canada ranked 18th out of 190 countries in the World Bank's Doing Business 2017 Report)
- Canada's manufacturing sector received the largest share of FDI (23%) in 2016
- The key foreign investors are large US companies in automotive, energy, banking, and retail

Ontario

Ontario is the largest Canadian province by population and GDP, representing around 40% of the Canadian total for each. Ontario is considered Canada's industrial heartland as 47% of Canadian manufacturing sales are generated in Ontario[3]. Ontario's GDP has grown steadily since the 2008 Financial Crisis - real GDP grew at 2.4% in 2017 but is expected to slow to 1.6% in 2018[1]. Unemployment reached a 17-year low of 6.0% in 2017, and is expected to continue its decrease to 5.3% in 2018[4]. The provincial government has put together an Innovation Agenda with the goal of seizing global opportunities. This strategy identifies target areas where Ontario would like to expand its innovation in industries, such as Pharmaceutical Research, Manufacturing, and Digital Media. The agenda has also identified the programs, regulations and investments that are required to catalyse growth in these areas.

Key Exports from Ontario 2016 (%)

2016
US$188.4 billion



Top Export Destinations (2016)

1. USA	80.9%
2. UK	6.7%
3. Mexico	1.7%
4. China	1.4%
5. Japan	0.9%

Source: Source from Ontario

Note: Others include vegetable products, plastics and rubbers, paper goods etc.
Source: Innovation, Science and Economic Development Canada

Strength in exports

- Ontario's exports are expected to rise by 1.8% annually[5] in the 2017-20 period. 88% of total export value in Ontario[5] comes from the manufacturing industry
- Ontario's exports tend to be high value-add products such as automotive, with a significant automotive manufacturing cluster based in Ontario

A top FDI Destination in North America

- Ontario is an attractive destination for capital investment, accounting for 8% of the total FDI into North America in 2016[6]
- FDI in 2016 reached US$4.5billion representing a 10% increase from US$4.1billion in 2015[6]
- Ontario accounted for 53% of FDI projects in Canada in 2016[6]

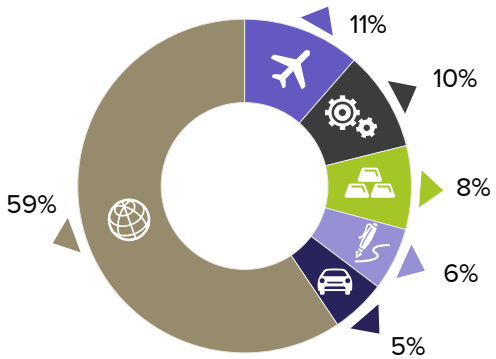
Quebec

Quebec is the second-largest manufacturing province in Canada, accounting for 24% of Canada's manufacturing sales revenue[3]. Quebec's economy is growing briskly with a growth rate of 3.2% in 2017 and a forecasted 2.0% in 2018[7]. The near term outlook for Quebec's economy is positive and expected to improve. The productive capacity of Quebec has tightened significantly, mainly due to a tight labour market that corresponds to an unemployment rate which is expected to stay below 6.0% until 2022[7], suggesting near full employment. This has led to an increase in wages and salaries, further driving a 7.4% increase in consumption spending in 2019[7].

Key Exports from Quebec 2016 (%)

2016

US$188.4 billion



Top Export Destinations (2016)

1. USA	71.0%
2. China	3.8%
3. Mexico	2.2%
4. France	2.0%
5. UK	1.7%

Source: Institute de la Statistique Quebec

Aircraft
Machinery and Equipment
Aluminium and aluminium products
Paper and paper products
Motor Vehicles
Others

Note: Others include vegetable products, plastics and rubbers, paper goods etc.
Source: Innovation, Science and Economic Development Canada

Uncertain growth in trade

- Quebec has faced challenges in its trading relationships with non-energy merchandise exports particularly due to currency appreciation and the uncertainty over NAFTA
- The aerospace and forestry industries (representing 20% of Quebec's exports in 2016) are currently the subject of anti-dumping and countervailing duty investigations by the United States. The aluminium industry (8.1% of Quebec exports in 2016) also faces the possibility of tariffs imposed by the US
- Despite these challenges, exports from Quebec are forecasted to grow by 7% in 2018[8]

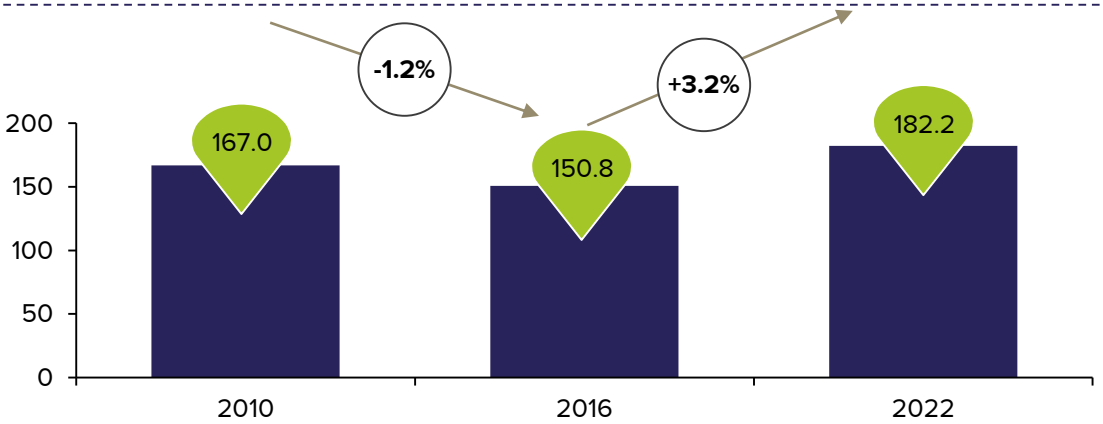
Sustained growth in business investment

- Quebec received US$1.35billion in FDI inflow in 2016, an increase of 35% from the previous year[9]
- The investments accounted for 15% of GDP growth in Québec and generated US$115million in tax revenue for the province[9]
- Total business investment is expected to grow by 3.4% in 2018, including increased investments by government-owned Crown corporations[10]

The evolution of Canadian manufacturing

The manufacturing sector is a significant contributor to Canada's revenue, exports and employment, accounting for 10.5% of Canadian GVA and 68% of exports in 2016[11]. However, the sector's GDP contribution has been steadily declining since 2000, when it represented 20% of GVA. Canada's monetary policy and currency exchange rate with the US dollar have a significant impact on the state of the manufacturing sector as the sector is highly export-dependent, with over 80% of manufacturing exports directed towards the US[12].

Figure 1: Canada's manufacturing is projected to recover from a downward trend
Manufacturing Value Added, 2010-22 (US$ billion)

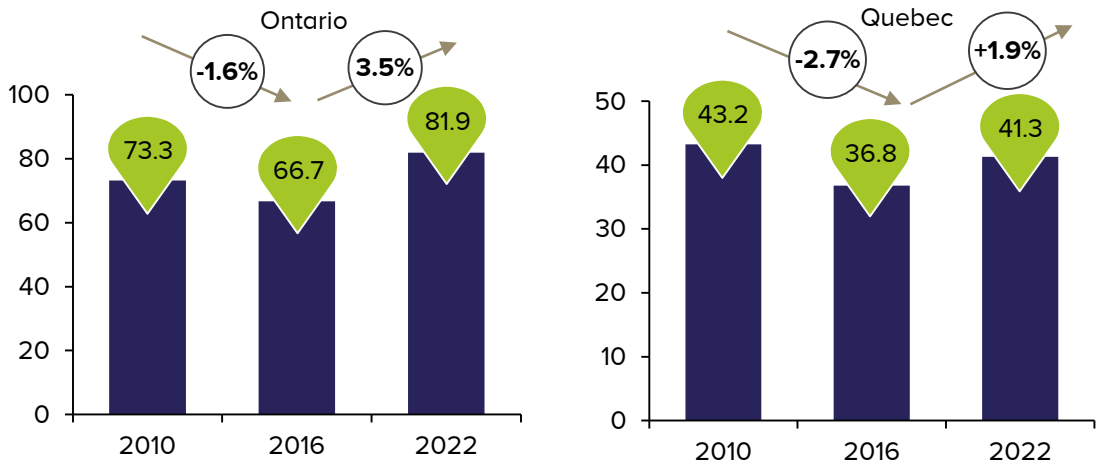


Source: World Bank, BMI

Canada is a global leader in investments that enable research, the transformation of new ideas into advanced products, and technologies that bridge the gap between research and marketplace applications. The manufacturing sector accounted for 32% of all business enterprise research and development investments in 2016, due to its focus on innovation and research.

Industrie 2030, an initiative by the Ministry of Science, Education and Economic Development and CME (Canadian Manufacturers & Exporters), has set the goal of doubling the value of manufacturing output by 2030. In order to achieve this goal, Industrie 2030 identified five key pillars including expanding access to domestic and foreign markets and building a strong, skilled workforce. The largest manufacturing sub-sectors in Canada are automotive, aerospace and machinery production.

Figure 2: Ontario and Quebec are the largest manufacturing clusters in Canada
Manufacturing Value Added, 2010-22 (US$ billion)



Source: World Bank, BMI

Manufacturing accounted for 9.4% of the jobs in the Canadian labour force in 2016 and employed 1.7 million people across the country. However, manufacturing's role as a source of employment has been declining steadily with a -1.2% CAGR between 2010 and 2016[14]. While Canada is a leader globally for the representation of women in its labour force, the manufacturing sector lags behind with Canadian women still representing only 28% of the manufacturing workforce[15]. The Industrie 2030 plan aims to improve the engagement of youth, women and under-represented groups in manufacturing to grow the size and skill of the domestic skilled labour pool.

Case Study: Canada's Federal Sustainable Development Strategy

Canada's approach to the UN Sustainable Development Goals (SDGs) was spelled out in the Federal Sustainable Development Strategy (FSDS) 2016-2019. The first Canadian Federal Sustainable Development Strategy was created in 2009 in response to the Federal Sustainable Development Act of 2008 (which mandated 26 departments and agencies to prepare their own sustainable development strategies.) The Act requires updates to the strategy every three years with the latest iteration covering 2016-2019. Canada's FSDS focuses on 13 goals, mostly in the environmental space and includes goals such as "Effective action on climate change" and "Clean Growth"[20]. The FSDS explicitly aligns itself to the SDGs. For instance, the "Clean Growth" goal is tied to UN SDG Target 9.5 "Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries" as well as UN SDG Target 12.6 "Encourage companies to adopt sustainable practices". The Safe and Healthy Communities goal is tied to UN SDG Target 12.4 "Environmentally sound management of chemicals and all wastes throughout their life cycle"[20]. Furthermore, the FSDS aims to work closely with the manufacturing sector on specific action areas such as investing in technologies to reduce greenhouse gases.

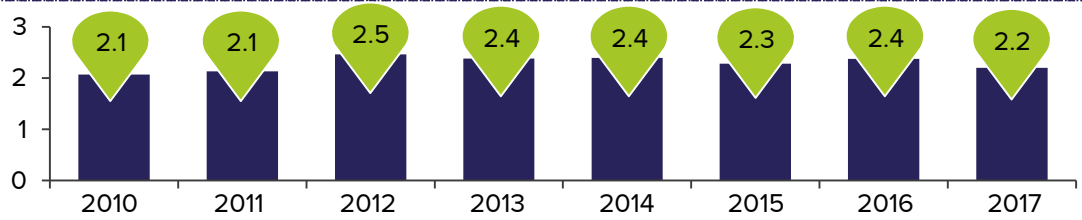
A Brookings Institute Working Paper that tracked Canada's progress on the UN SDGs found that of the 73 SDG targets that were relevant to Canada, 17 were on track, 12 needed acceleration, 26 needed a breakthrough and 18 were moving backwards. Specifically, within SDG 9 Industry, Innovation and Infrastructure, the number of full time R&D workers grew from 3,900 in 2003 to 4,519 in 2012 but Canada was not on track to achieve the target of 6,779 by 2030[21]. Furthermore, the share of GDP spending on R&D fell to 1.6% in 2014 from 2.0% in 2004[21]. In trying to progress on SDG 12 Responsible Consumption and Production, the paper found that solid waste per capita declined 10% between 2004 and 2014[21]. In general, Canada follows a process for reporting its progress on targets to the UN Commission on Sustainable Development. Canada is also openly committed to helping developing countries in achieving the UN SDGs, in particular through its Official Development Assistance (ODA) program.

The manufacturing sector in Ontario

Ontario is the largest manufacturing province in Canada in terms of output and employment. Manufacturing accounted for 12.6% of total GVA in 2016[16]. The United States accounted for 82.8% of the total value of provincial exports[17], with automotive, machinery and electrical equipment serving as the major categories.

Automotive

Figure 3: Canada's Vehicle Production, 2010-17
(million units)



Source: BMI

Canada is the fourth largest auto exporter in the world by value. The sector is highly concentrated in Ontario, enabling easy access to the US market, especially the major auto hub in Detroit with the largest American car manufacturers. Five OEMs - Chrysler, Ford, GM, Honda and Toyota- operate 12 plants in Ontario. The major Canadian automotive companies include Magna, Bombardier and Linamar. The automotive sector in Ontario employs 104,000 autoworkers[18] and boasts several universities and vocational colleges creating a pipeline of highly skilled talent as well as 24+ auto-focused public research facilities.

Machinery

Figure 4: Canadian Machinery Export, 2010-16
(US$ billion)

Source: UN Comtrade

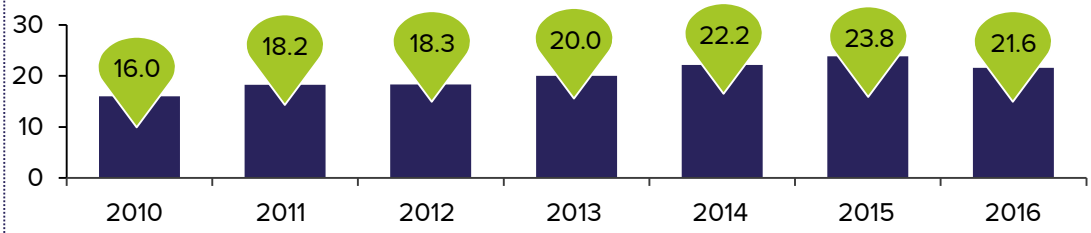
The Canadian economy is specialised in machinery-intensive industries. Main industrial products include pumps and compressors, rolling-mill and metalworking equipment, forestry equipment, mining equipment, farm machinery and construction equipment. The natural resources sector is a strong source of demand for Canadian machinery. 64% of the machinery and equipment sector is located in Ontario[17] (based on dollar value of plant shipments), with the largest Canadian machinery and equipment companies being Babcock-Wilcox, Dorr-Oliver and Black Clawson-Kennedy.

The manufacturing sector in Quebec

As the largest province by area, Quebec has a major manufacturing sector that accounts for a quarter of Canada's manufacturing output. Manufacturing is a key sector in Quebec, accounting for 13.9% of total GDP. The highest valued export sectors are aerospace and machinery and equipment (M&E).

Aerospace

Figure 5: Canada's Aerospace Revenue, 2010-16
(US$ billion)



Note: Conversion rate C$1= 0.8 US$
Source: Innovation Science and Economic Development Canada

Canada was the world's fifth largest aerospace market and third largest civil aircraft manufacturer in 2016. Quebec accounted for 60% Canada's production and 55% of employment in aerospace[19]. 80% of Quebec's production is directed towards exports, mostly to the US. 60% of aerospace exports are aerospace components such as aero-engines, avionics and landing gears[19]. The largest Canadian aerospace companies include Bombardier, Bell Helicopter and Pratt & Whitney Canada.

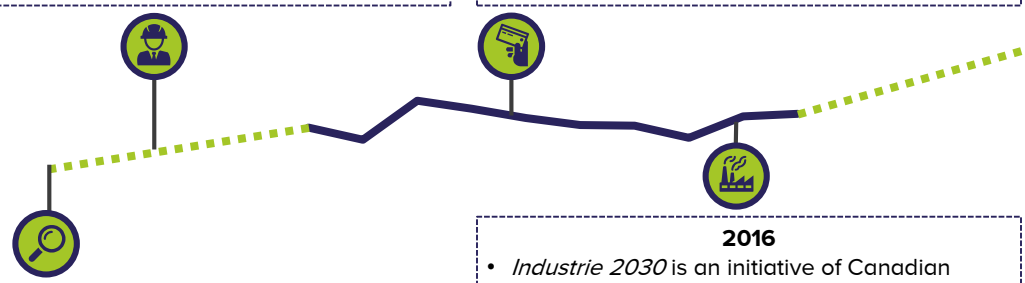
The Leap Forward

The changing nature of technology and the global economic environment are creating the need for a transformation in the nature of Canadian manufacturing. Canada must leverage its comparative advantage in R&D and digital skills to create and drive innovative new processes and products for growth. Industrie 2030 is a critical first step in the right direction, but Canada will need to create the conditions and support systems to drive adoption of the Fourth Industrial Revolution, especially amongst SMEs. Canada must also strengthen its world-class aerospace hub in Montreal and drive competitiveness through innovation and diversification of exports. Furthermore, it must look to create the manufacturing workforce of the future that is a better representation of its population and that is able to adapt to the changing needs.

Figure 6: Canada's manufacturing industry will continue its recovery and growth
Four key milestones for Canada's manufacturing in its development

2004
- Manufacturing 20/20 is an initiative by *Canadian* Manufacturers & Exporters (CME) that has released the most extensive consultations undertaken by the private sector in the history
- Objectives include the development of a long-term vision, raise awareness and connect manufacturers with stakeholders from education institutions, labour groups and government

2011
- The Canadian government commissioned an expert panel to conduct a comprehensive study and released a report 'Innovation Canada: a Call to Action', which recommends for a Scientific Research and Experimental Development R&D tax credit program, in which $6.5 billion worth of tax credits and other incentives will fund private sector R&D efforts.



1994
- North America Free Trade Agreement (NAFTA), a trilateral trade bloc among Canada, Mexico and the US
- The goal is to remove trade barriers across the region to exchange goods and services
- NAFTA is one of the world's largest free trade zones

2016
- *Industrie 2030* is an initiative of Canadian Manufacturers & Exporters (CME) with the objective to create a roadmap to double value-added manufacturing, processing, technology and services in Canada by 2030
- Key objectives
  - Retain and attract investment & expand capacity
  - Manufacture more new products/technologies
  - Accelerate adoption of new technologies
  - Sell more in Canada and around the world

The future of Canadian manufacturing will be shaped by three trends:

A. Championing widespread adoption of Industry 4.0 by SMEs: Investment in Industry 4.0, especially by SMEs, will help drive industry productivity and innovation

B. Strengthening global leadership of the aerospace sector: Further enhancement of Montreal's role as a hub for aerospace based on its ability to innovate and diversify

C. Developing the manufacturing workforce of the future: Proactive action to increase the size and skill level of the Canadian manufacturing workforce to be future-ready

A. Championing widespread adoption of Industry 4.0 by SMEs

Canada is focused on its Industry 4.0 vision and has developed a number of programs to drive efforts in this direction. “Industrie 2030”, a national strategy for Canada’s manufacturing industry developed by the Canadian Manufacturers and Exporters (CME), targets to double manufacturing output and exports by 2030. Among five key themes outlined, “Accelerating Adoption of Advanced Manufacturing Technologies” is one of them, recognising the need for Canada’s manufacturing industry to be at the forefront of adopting advanced technologies for its long-term competitiveness.

Specifically, in the province of Ontario – which contributes 44.2% of Canada’s manufacturing value-added and is the location of 40% of nation's manufacturing companies[22]– an Advanced Manufacturing Supercluster was formed to focus on building next-generation manufacturing capabilities, incorporating technologies like advanced robotics and 3D printing[23]. This is a business-led initiative that seeks to bring together Canadian businesses of all sizes, academic institutions, and not-for-profit organisations to form a regional innovation ecosystem.

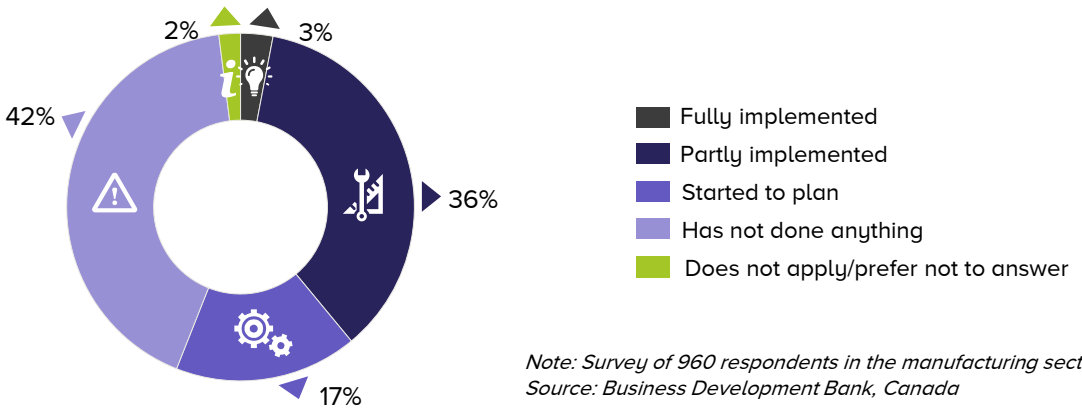
To apply research findings in the marketplace and ensure that benefits of R&D are experienced by the people, the National Research Council (NRC), the primary national research and technology organisation in Canada, has set up collaboration platforms across the country[24]. Its newly set up facility in London, Ontario features an open-space concept workspace for all levels of the automotive supply chain to collaborate with NRC and other Canadian research organisations, focused on helping automakers adopt advanced manufacturing approaches, such as mass customisation, data-driven factory automation, manufacturing with new materials and setting up digital factories to produce transportation technologies such as Connected / Autonomous Vehicles (CAV).

However, Canada still has much to do. Its manufacturing sector lags behind most developed nations[25] in terms of its use of industrial robots. Furthermore, investments in machinery and equipment have dropped between 2009 and 2014[26]. About 60% of Canadian businesses do not presently use advanced manufacturing technologies in their operations[26]. SMEs in Canada’s manufacturing industry are a large part of the reason that the nation is behind the curve globally in adopting Industry 4.0 technologies and underinvesting in advanced technologies[26]. SMEs (less than 500 employees) represent about 99.4% of the manufacturing companies in Canada, and similarly dominate (99.6%) in Ontario. Only about 39% of Ontario’s businesses have implemented Industry 4.0 technologies while Quebec leads the nation with 45%[25].

With SMEs’ exports making up 25% or $106billon of total exports in 2013, and small businesses (fewer than 50 employees) making up 30% of GDP, their lagging adoption of advanced technologies is a considerable challenge which Canada needs to overcome, to ensure comprehensive adoption of Industry 4.0[27].

Figure 7: The potential of digital technology in the manufacturing sector is underutilised
Responses (%), 2016

To what extent have you implemented Industry 4.0 projects in your company?



Note: Survey of 960 respondents in the manufacturing sector
Source: Business Development Bank, Canada

Focus Areas

Create shared resource centres for SMEs to implement Industry 4.0

Low productivity is a persistent concern for Canada's manufacturing industry[28] and this has left it exposed to competition from low-cost manufacturing countries, especially for smaller companies. The adoption of Industry 4.0 technologies can potentially improve productivity by reducing resource consumption and waste, especially if integrated throughout the supply chain to drive efficiencies. In addition, Industry 4.0 tools can also help better address evolving customer needs to drive revenue growth.

In implementing these innovations, SMEs face a wide range of challenges (as compared to large companies) which includes limited capital, low technology capabilities and limited talent availability. They also have fewer opportunities for testing and understanding how these new solutions fit into their operations to determine the real value of each solution.

Building shared SME resource centres can help overcome these hurdles. SME resource centres provide access to Industry 4.0 tools, software and training programs. The centres can offer solutions and tools on lease (e.g., SaaS solutions), reduce costs for testing and training, and drive shared learning. The centres can also provide SMEs access to technology know-how, best practices and can feature a specialist team to provide guidance on implementation processes – from systems installation and understanding process requirements, through to change management and how to successively bring other technologies on board.

Overall this allows SMEs to make informed decisions in identifying most value-added solutions to their business with access to test, examine and apply new technologies, which lowers risks of wrong and expensive investments, while helping to overcome capital constraints and the significant investment associated with each purchase. From a funding perspective, SME resource centres can potentially increase the availability of funding as it presents a coordinated effort to adopt advanced technologies, thereby instilling greater credibility for funding by banks and credit unions.

The centres can be built by leveraging on existing collaboration solutions and advanced manufacturing superclusters and could be organised by sectors such as the Automotive Industry 4.0 SME resource centre in Ontario and Aeronautic SME Industry 4.0 resource centre in Quebec. They can also leverage on specialist knowledge available in existing research centres such as the Initiative for Automotive Manufacturing Innovation (IAMI), University of Ontario Institute of Technology, Fraunhofer Project Centre @ Western and the Automotive Centre of Excellence.

Finally, the presence of a centre of shared learning increases collaboration and knowledge exchange which is particularly important to help the nation move beyond deployment of individual technologies and tools to consider the interlinkages between the tools, and applications in smart factories, digital supply chains and digital product offerings, in order to realise the full benefits of Industry 4.0.

Create an 'Industry 4.0 SME toolbox' that fosters the adoption of Industry 4.0 within Canada

Industry 4.0 technologies drives data capture and generates insights that feeds into business and manufacturing planning to enhance decision making, customer relationships and asset utilisation as well as improving production processes and products. For example, Ontario-based Raven Telemetry AI developed a solution that interprets large amounts of raw data in real time and sends it to process 'drivers' such as shop-floor supervisors and operators, delivering directions they can act on, accelerating decision-making, problem-solving and production[29].

However, managing large amounts of data and its associated technical requirements is challenging. Data privacy and cybersecurity issues as well as operational disruptions caused by data breaches are persistent concerns. These problems are further exacerbated by the lack of regulatory and technical standards. The lack of a central governing body at the industry or government level to set technological standards hinders interoperability of new Industry 4.0 systems across value chains, while adopting new technologies in an uncertain, emerging regulatory environment cause disruptions to existing modes of operation. Technical standards in areas such as Reference Architecture and Industrial Communications have not yet emerged in Canada and divergent standards could hinder the integration of digital supply chains. Currently, Canada lags in implementing Industry 4.0 standards which have been created in Germany, US and China. All of this could deter Canadian companies, especially SMEs, from adopting Industry 4.0 technologies.

To handle data management issues requires legal, cybersecurity and technical expertise to help navigate legal and operational risks. Smaller companies are less likely to have access to required resources and capital as compared to larger companies. Available government support is also currently more focused on 'traditional' R&D rather than on new technologies.

Creating an "Industry 4.0 SME toolbox" incorporating legal advice and funding resources can help SMEs. The "legal toolbox" should first stipulate existing laws as well as emerging international standards in Industry 4.0. It must be usable in clearly laying out restrictions and indicating what is possible to do in common scenarios. When setting out legal standards for Industry 4.0, there should also be room for flexibility to encourage continued innovation.

The legal toolbox should also address emerging international standards. The Canadian government can engage with leading platforms such as Germany's *Plattform Industrie 4.0*. International organisations such as the World Wide Web Consortium (W3C) and Industrial Internet Consortium (IIC) also have established global standards for the web and industrial internet that Canadian SME consortiums and associations can further engage with.

Providing more accessible funding as part of the "Industry 4.0 SME toolbox" should be another focus area. One way is to provide direct transfer funds which can better cater to the smaller scale of SME companies as they could otherwise find tax incentives less useful. Funding can be further prioritised among SMEs based on the company's importance to the industry supply chain, and if they are amongst targeted/prioritised industries.

Another way is to expand existing R&D funding programs to include domestic SMEs – such as the "Scientific Research & Experimental Development Tax Incentive" (SR&ED), Canada's tax incentive program to encourage Canadian businesses to conduct R&D in Canada and "SMART", Southern Ontario's only program that provides grants and technology assessments for new technologies - successful models that encourage foreign companies to conduct R&D in Canada. The Canadian government could also look into funding R&D efforts that are conducted not only in labs but expand it to include business-led R&D conducted in factory floors. Overall, these strategies will better equip Canada's SMEs and accelerate their adoption of Industry 4.0 technologies.

Case Study:
European Commission launches cross border partnership to drive SMEs' adoption of Industry 4.0

The European Commission initiated the Smart Specialisation Platform (S3P) in 2011 with a focus on the theme of 'SME integration to Industry 4.0', a strong recognition of the value of digitalisation to the economy and the crucial role that SMEs play. The OECD estimated that the digitisation of products and services could add more than €110 bn (US$132billion) of revenue to the European economy between 2017 and 2022. The role of SMEs was further highlighted in the G20 Germany Presidency report that emphasized the need for SMEs to rapidly adopt new technologies. The report found that, while the scale of SMEs was hindering their ability to fully reap the benefits of the digital economy, the associated potential benefits would still be numerous for SMEs. The European Union (EU) also recognised the role of cities and regions in fostering an environment that would create the conditions for digitisation of SMEs. Specifically, economically weaker regions that were able to promote digitisation among their SMEs would be able to overcome other barriers to their growth.

The 'SME integration to Industry 4.0' theme was highlighted to address the above concerns, with a mission statement of "Increasing Industrial Competitiveness in EU regions by raising awareness of Companies (SMEs) for -and demonstrating to them the benefits of- Industry 4.0 solutions/technologies".

It is a cross regional partnership with regions and member states working across Europe to drive the initiative. The co-leading members are currently Castilla y Leon, Catalonia, Mazowieckie, Slovenia, Tuscany and Valencia with six other regions already participating and more than ten regions interested in joining the partnership. The partnership has a market-oriented approach and is focused on driving the competitiveness of SMEs. It does this by recognising the importance of SMEs to the value chain, enabling improved products and services, reduced costs, better management of operation and increased competitiveness. To this end, the partnership has three strategic axes.

Key Strategic Axes:

 Awareness	 Platform	 Projects
• The partnership recognises the importance of making SMEs aware of the opportunities created for them through the implementation of Industry 4.0. • Through its regional, cross-European approach, the aim is to encourage SMEs to recognise the value of cross border cooperation in these fields.	• A digital ecosystem has been created based on The Open Source Platform. It enables collaboration of SMEs with sectoral clusters and centres of excellence. • Software as a Service (SaaS) has allowed SMEs in participating regions to increase innovation without having to make burdensome investments in infrastructure or securing licenses.	• Tools and enabling technologies that are well suited to SMEs' needs are promoted to them, and encouraged to be integrated into existing operations. • The initial focus in technologies has been on Production Performance Monitoring Systems (PPMS) that allow for the streamlining of existing processes.

The initiative has already started work on the transformation of particular value chains across the regions such as Production Performance Monitoring Systems (PPMS) for the metal machining industry, and predictive modelling and maintenance for the automotive, agricultural and food manufacturing, machinery and energy production.

Note: Exchange rate is based on 2016 (€1=US$1.20)
Source: Smart Specialisation Platform, Interreg Europe

B. Strengthening Canada's global leadership in the aerospace sector

The aerospace sector is a key contributor to Canada's economy totalling US$28billion in GDP contribution and provides for 208,000 jobs, according to 2016 estimates. The sector has also experienced strong revenue growth of almost 20% between 2011 and 2016[30].

Canada's aerospace industry is amongst one of the world's few top aeronautics hubs, with a main presence in the province of Quebec, Montreal city, accounting for around 60% of Canada's total production. The majority (80%) of Quebec's aerospace production are for exports, primarily to the United States. More than half (60%) of Canada's aerospace exports are aerospace components[30].

Quebec's highly developed aerospace sector can be attributed to a few factors. Firstly, it is equipped with a highly skilled labour force where close to 5,000 new aviation graduates join the workforce annually[27]. This is supported by world class aviation institutions such as the McGill's Institute for Aerospace Engineering.

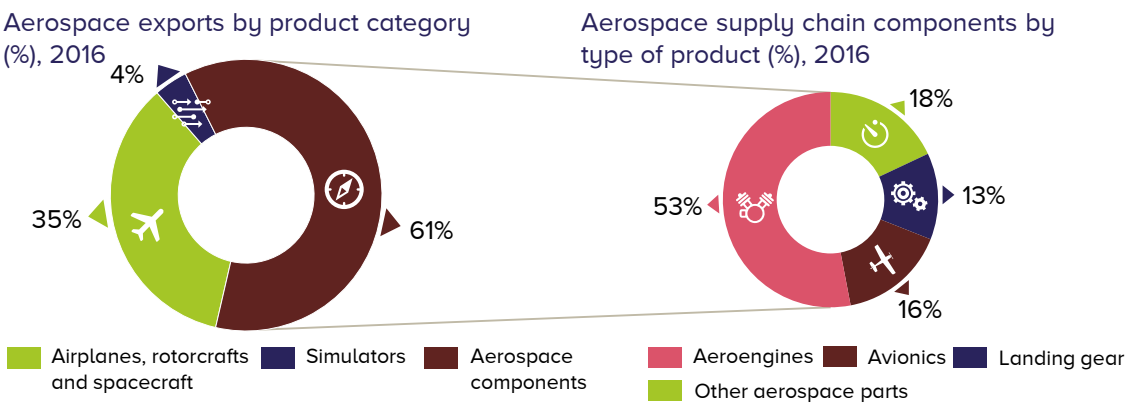
Secondly, there is a strong emphasis on research and development (R&D) in the aerospace industry. In 2016, the aerospace sector registered the highest R&D spend, accounting for almost 30% of the manufacturing industry's total R&D spend. A majority (70%) of the aerospace R&D investments are focused in Quebec[30].

Thirdly, the Canadian government provides strong policy support and funding to the aerospace industry. The Quebec Aerospace Strategy is a ten-year plan that outlines ten key objectives and investments totalling US$2.3billion (C$2.8billion) to help the aerospace industry adapt to major global trends and further position Quebec as a global aerospace hub.

However, there are potential risks that the Canadian aerospace industry is exposed to, pertaining to the uncertainty of Canada-US trade relations, and increased competition from US domestic production. The Canadian aerospace manufacturing sector is highly dependent on exports and especially reliant on the US as its main demand market. About 60% of the Canadian aerospace production is exported to the US[31]. This exposes Canada to rising protectionism in the US and Canada-US trade policy changes. For example, in 2017, US authorities threatened to impose up to 300% tariffs[32] on Canadian company Bombardier's sale of its C-series jets to American Delta Airlines, after it was ruled that Bombardier was selling the commercial aircraft jets below cost as a result of receiving major subsidies from the Canadian government. The petition was eventually rejected by the International Trade Administration.

This risk is further amplified by the increased focus from the US government on boosting domestic manufacturing. The "America First" campaign features tax reductions for businesses and encourages the reshoring of manufacturing and investments back to the US. These measures could possibly reduce the US's reliance on Canada's imports, and crowd out opportunities for Canadian manufacturers. To mitigate the potential risks that Canadian aerospace industry is exposed to, it is vital to explore new market opportunities and diversify Canada's export portfolio.

Figure 8: Aerospace components make up 60% of Canadian aerospace exports



Source: Innovation, Science and Economic Development Canada

Focus Areas

Expand presence in new destinations to seize market opportunities and minimise risks

In line with a global shift in aviation demand, emerging markets have become new drivers of demand growth and as a result new aerospace manufacturing hubs have emerged. Emerging markets are leading growing demand in civil aviation, predominantly in Asia. According to the International Air Transport Association, China is set to overtake the US as the world's largest aviation market with the highest volume of passengers in 2024. Boeing forecasts that in the next 20 years, Chinese airlines are expected to purchase commercial aircrafts in excess of 7,000 units worth about US$1.1trillion[33].

Additionally, the global defence market is set to grow driven by increased defence spending in the US and Europe. The North Atlantic Treaty Organization (NATO) estimates that its members (excluding the US) will increase their defence spending to about US$300billion in 2017[34].

Corresponding with demand growth, aerospace and defence manufacturers have invested into new markets. For example, Airbus became the first foreign manufacturer to set up manufacturing facilities in India in 2015. Meanwhile, some of the new demand markets have set up their own manufacturing companies. For example, in 2008, China formed its state-owned aerospace manufacturing company, Commercial Aircraft Corporation of China (Comac) to design and construct large passenger aircraft, thereby reducing its dependence of Boeing and Airbus.

This creates new market opportunities for Canadian aerospace suppliers to provide components to the aerospace manufacturers looking to expand their presence in new markets. As aerospace original equipment manufacturers (OEMs) like Airbus and Boeing expand their presence in growth markets such as China, Canadian suppliers can positon themselves well by providing sophisticated components with advanced technological capabilities to the OEMs and help them establish unique value propositions and stronger competitive edges. For example, in 2017, a Chinese state-owned aircraft leasing company, China Aviation Supplies Holding, signed a deal with Boeing to buy 300 planes worth US$37billion[35]. Boeing's largest supplier base is in Canada, with more than 200 major suppliers and more than 600 suppliers across the country[36].

In addition, Canada's major aircraft manufacturers such as Bombardier can potentially supply directly to emerging markets. One way to access a new market is via partnerships. In 2011, Bombardier signed an agreement with Comac to establish a long-term strategic cooperation which includes knowledge sharing and R&D, through to marketing, and customer relationship management. Finally, Canada's aerospace companies can also prioritise markets of entry based on existing trade policies. For example, the Comprehensive Economic and Trade Agreement (CETA), a new free trade agreement enacted in 2017, eliminates 98% of trade tariffs between Canada and EU37. Therefore, Canadian aerospace suppliers can leverage low or zero tariffs to supply cost effective aerospace components to OEMs based in Europe. Airbus is one such example of an OEM that assembles in multiple EU countries such as France, Spain and Germany.

Develop new technologies and cater to the growing demand in new market segments

Diversifying into new market segments driven by emerging technologies can provide an additional growth opportunity for Canada's aerospace industry.

Unmanned Aerial Systems (UAS), also known as drones, is a new growth segment in which investments are soaring globally. The UAS global market is anticipated to reach US$25billion by 2023 at a forecasted compound annual growth rate of 18.2% between 2017 and 2023, primarily driven by the commercial sector[38]. Market demand has shifted away from military use towards commercial uses – for both corporate and consumer applications across multiple industries.

Canada is already focusing on strong efforts to tap in the UAS market. The government has allocated a US$0.83million (C$1million) investment to develop a regional ecosystem for commercial and civil UAS, also part of its ten year Aerospace Strategy 2016 to 2026 plan. In addition, a new UAS centre of excellence has been set up in Quebec this year for testing and developing drones to better position as an international centre of services and innovation for the global UAS market.

Another emerging segment is the green aviation market, which has developed along with growing global environmental concerns as the aerospace sector registers a heavy carbon footprint. The European Commission's aviation plan "Flightpath 2050" maps out a significant commitment to cutting emissions and pollution - CO2 by 75%, NOx by 90% and noise by 65%. Canada has also responded by establishing the Green Aviation Research and Development Network (GARDN) to drive continuous efforts in the development and use of green and alternative fuels, innovate lighter materials and quieter engines.

Overall, Canada is well positioned to establish a strong foothold in new market opportunities. Its strong focus on aviation R&D, skilled talent pool, world class university aviation programmes, and presence of a concentrated cluster of more than 13,000 engineers and scientists in the aerospace sector provide a conducive environment to accelerate its efforts in the UAS and green aviation market spaces.

However, the development of new emerging technologies require significant investments, especially in developing prototypes for testing, in particular for aerospace manufacturing. To address this, more innovative R&D funding models incorporating a mix of public and private funds could help better focus R&D priorities on areas that align with market demand.

Another way to significantly reduce R&D costs incurred in prototyping and production is to leverage existing capabilities in Industry 4.0 technologies. The adoption of technologies such as 3D printing helps develop flexible production systems that reduces costs, improves quality and boosts productivity in adopting new emerging technologies.

To reinforce its position to tap into new market segments, Canada can also build on its existing aerospace ecosystem by driving greater engagement and a concerted effort across public and private sector stakeholders. For instance, Canada's aerospace strategic think tank, Aero Montreal, which brings together key industry stakeholders of companies, educational and research institutions, associations and unions, can play a central role to better connect different industry stakeholders.

Different stakeholders can also look to play complementary roles. For example, the government can establish policies focused on the development of growing technologies and innovation, while large aerospace companies can accelerate the overall development of the Canadian aerospace industry by sharing technology know-how with smaller and medium sized companies.

Case Study:
City of Seattle in Washington, US is the aerospace capital of the world

Seattle and Montreal are among the world's few top aerospace manufacturing hubs. Seattle in the Washington, US, has the largest aerospace cluster with 1,400 aerospace firms employing around 93,800 workers. The Montreal aerospace industry is comparatively smaller with more than 200 companies and provides for 39,130 jobs in Canada. Both hubs have a highly skilled labour force and a strong R&D focus.

The concentration of aerospace presence in Quebec, Montreal, is backed mainly by strong government support while Seattle's aerospace sector is anchored by Boeing, the world's largest aerospace manufacturer based on revenue and plays a key role contributing to the development of its aerospace industry. Boeing has anchored the growth of the industry cluster in Seattle by locating three of its five business units' global headquarters and all final assembly facilities for its commercial jets there. Quebec's largest domestic aerospace manufacturers Bombardier and Pratt & Whitney are comparatively smaller in revenue size and production volume.

The US government has also in place a full-fledged strategy for its aerospace sector with the Washington Aerospace Industry Strategy plan that maps out key objectives for the sector annually. One of the key objectives include the increased engagement of industry stakeholders, which has been exemplified by the formation of The Joint Center for Aerospace Technology Innovation (JCATI) in 2012. The JCATI is a partnership between industry and academia to facilitate the development of new technologies and maintain Washington's leadership in aerospace innovation. The centre pursues joint industry-university research programs and facilitates the identification of research priorities and needs by connecting with aerospace firms across the cluster. An organisation with a similar focus in Canada, Aero Montreal, is a strategic think tank set up in 2006 to mobilise major organisations including companies, education and research institutions, associations and unions to support its growth on a global stage.

Figure 9: Aerospace ecosystems involve a number of stakeholders in Montreal and Seattle

Similar to Montreal's efforts in green aviation development with the formation of GARDN, Seattle has also made headway into green aviation development where its private sector has taken on significant roles. In 2009, the US aerospace industry launched an initiative called *Greener Skies over Seattle*, a collaborative project involving private and public sectors in the aerospace industry, including the US Federal Aviation Administration, Port of Seattle, Boeing, Alaska Airlines, and other American airlines. The effort saw the development of a satellite guided technology, Required Navigation Performance (RNP) that improved the efficiency of flight landing and reduced fuel usage, carbon emissions, noise pollution and time. Seattle has also established capability in a growing new opportunity segment in Unmanned Aviation Systems, largely led by Boeing's acquisition of Insitu in 2008 for US$400million. Insitu is a pioneer and leader in the design, development, production and operation of UAS. The company manufactures UASs for weather and environmental reconnaissance, defence and search and rescue efforts.

Source: Washington Governor's Office of Aerospace, Trade Development Alliance, company websites

C. Developing the manufacturing workforce of the future

The nature of jobs in the manufacturing sector is rapidly changing with the adoption of digital adoption and further automation. As such, the manufacturing workforce requires upskilling to learn and adapt to these changes, for example, to manual and routine tasks being automated, and also to have a range of skill sets and be versatile to perform a variety of tasks.

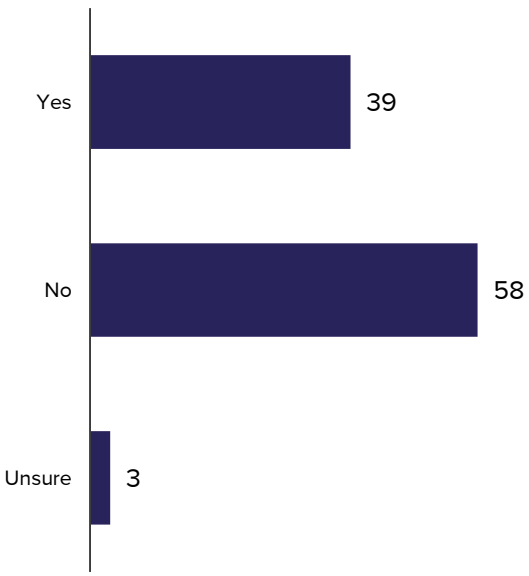
While automation is commonly thought to replace jobs, this largely depends on whether the new technology is a substitute for, or a complement to, human labour. Some innovations require greater human-machine collaboration such as working with robots on fulfilling tasks and to train, repair and maintain robots. In fact, robotics-intensive sectors employ 20% more engineers and pay higher wages than other manufacturing sectors, according to a PwC report on American manufacturing companies[39].

There is a current shortage of skilled labour in Canada's manufacturing sector, and is most pressing for machinists, millwrights and industrial mechanics, welders and manufacturing managers[40]. These roles are skilled positions and will need to be replaced by younger, technically-skilled workers, especially in the era of advanced manufacturing where production processes are more complex and require greater expertise[41].

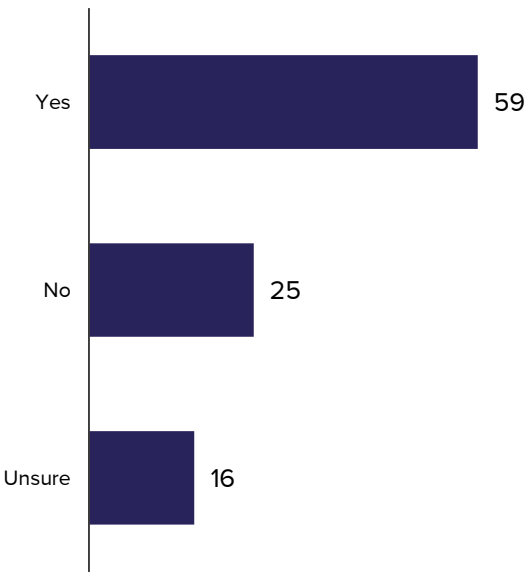
The shortage of skilled labour due to Canada's aging population, and a higher share of workers (>20%) aged 54 years old and above compared to other industries; has resulted in higher turnover rates and the erosion of institutional memory within the manufacturing sector[41]. In addition, there is a perception bias against manufacturing jobs as employees are viewed as traditional 'blue collar which negatively impacts the industry.

Figure 10: Manufacturing companies anticipate workforce challenges in the near term
Responses (%), 2016

Does your company face immediate labour or skills shortages?



Do you anticipate labour or skills shortages within the next five years?



Source: Canadian Manufacturers & Exporters

Focus Areas

Create a talent pipeline for manufacturing that recognises the evolving needs of the industry

The priority would be to develop new skills in Canada's manufacturing workforce and keep them effective in the face of emerging trends such as digitisation and disruptive innovations. However, current worker training and re-training programs may be insufficient to contend with escalating requirements in the manufacturing workplace. Less than 30% of workers in Canada participate in job-related education and training, compared to about 35% in the United Kingdom and close to 45% in the United States[40]. Spending on workforce training and skills development by Canadian organisations decreased by nearly 40% since the early 1990s[41]. Reasons that manufacturing companies cite that deter from investing in training are related to programs not fitting with business needs, the lack of financing, and concerns about losing workers after they are trained[40].

The government can play a key role in upskilling Canada's manufacturing workforce by increasing funding of relevant training programs. One example is the nation-wide Work Integrated Learning Program (WILP) introduced in 2015 which is part of the STEM education program.

Targeted at tertiary students, the program requires them to study for six months and then do a six month work stint. Such programs attracts younger workers who will be better equipped with digital skills and more relevant for technology-led evolution in manufacturing.

The government can also work with companies to identify gaps in training courses incorporating periodic reviews to more closely respond to changing technologies and market trends. This will reinforce Canada's current alignment to one of United Nations (UN) Sustainable Development Goals (SDG)'s goal of "promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all", which sets out an ethos of lifelong learning and responsiveness to changing industry needs.

Training programs should also be well integrated with application know-how and should equip workers with the knowledge of technology-driven tools (e.g., virtual reality and micro-learning) that will support on-the-job training. Another method of training can be via mentorship programs, where more experienced workers in the industry train younger workers - also a good way to document institutional memory.

Position manufacturing jobs to attract more women

Women account for almost half (48%) of the total workforce in Canada, but make up only one in four (28%) of the manufacturing workforce[15]. Attracting more women to manufacturing would increase the size of its workforce, but since the mid-80s, female participation in the manufacturing workforce has been flat and is expected to further decline by 2035[15] if the current pool of female workers retiring and leaving the workplace are not quickly replaced. Smaller companies have made no progress in increasing female employment even though women are more likely to work in SMEs (29%) than in larger companies (24.6%). This is especially since SMEs make up 96% of manufacturing companies in Canada[15].

In order to achieve Canada's goal of doubling output in the manufacturing sector as set out in the Industrie 2030 strategy, and reinforce its alignment to the UN SDG's goal to "achieve gender equality and empower all women and girls", it must surely look to leverage this half of its workforce and ensure equal opportunity. With women representing the majority of university graduates in Canada, they can also play a critical role in higher skilled roles such as product design, computer programming.

One way to increase the share of women in manufacturing is by driving a focus in Science, Technology, Engineering and Mathematics (STEM) education among women across educational levels. Currently, women make up less than 17% of graduates in architecture, engineering and related technologies[15]. A number of ways to do this include driving engagement among girls in science classes, and increasing exposure to female participation in manufacturing and related areas through various initiatives such as by hiring more female science and mathematics teachers and professors.

Businesses can also put in place robust corporate policies to improve workforce conditions for women, such as ensuring equal pay regardless of gender based on performance and merit, and the provision of maternity leave and flexible working hours for those with children.

Empower immigrants to take on roles in manufacturing

Immigrants represented 20.7% of the Canadian population in 2011 and this proportion is expected to increase to between 24.5% and 30% by 2036[42]. In urban areas, this proportion is likely to be even higher. The immigrant population will become an increasingly important pool that manufacturing companies can draw upon to increase the size and skill of their workforce.

Canada is already a pioneer in developing programs that promote the assimilation of immigrants into the workforce. Many initiatives provide training and employment services to immigrants such as language skills, communication and workplace culture skills and job assistance support.

However, gaps in the system still exist as immigrants often face additional challenges in accessing and performing jobs in the manufacturing sector. A 2011 study found that male employees who immigrated as adults were 25% less likely to receive job training than their Canadian-born counterparts[43]. The main barriers for job-related training for immigrants in Canada are family responsibilities and financial constraints.

A national program targeted at upskilling immigrants can ease talent challenges faced by the manufacturing sector. A successful program can be business-led involving manufacturing companies, particularly SMEs at the earliest stages, so that training curriculums are better aligned to market demand. These programs should also provide opportunities for re-training in both technical skills and social skills. Scaling of initiatives such as the Manufacturing Refugee Training and Employment Program (RTEP) run by Mosaic, a charity for immigrants, newcomers and refugees in Vancouver, and the BC Alliance for Manufacturing can be a first step. The Manufacturing RTEP is a two-month training program that offers basic production training as well as job-readiness, language and workplace communication skills. The program also offers one year of ongoing consultative support[44].

Case Study:
Singapore's Competency Credentialing System drives upskilling and lifelong learning

The Singapore Workforce Skills Qualification (WSQ) is a national credentialing system that serves to standardise continuing education and training for the workforce. The WSQ system helps identify skill and competency gaps in the market and creates a structured way in which these skill gaps can be filled. The WSQ system is competency-based and is created around requirements for specific jobs, which allows it to be responsive to changing market needs around emerging technologies and new capabilities.

There are 25 areas or industries in which individuals can pursue a WSQ, which covers technical skills required for particular industries and generic skills that are applicable across industries to improve overall job performance. Its technical skills program caters to four industries with specific areas of qualification for each industry.

Industries of Focus – Manufacturing:

Aerospace	Generic Manufacturing	Precision Engineering	Process
• Aircraft Maintenance • Fleet Management • Engine Maintenance • Manufacturing	• Assembly and Test • Process • Wafer fabrication • Generic Manufacturing	• Technical and Engineering • Management	• Engineering Services • Chemicals • Pharmaceutical Manufacturing • Biologics • Environmental Technology

Courses adhere to standards set out in the WSQ and are offered in modules so that individuals have the flexibility to pursue courses at their own pace. These courses are run by Approved Training Organisations (ATOs) which could be companies operating in the field, private training and vocational colleges or public institutions. There are several qualification levels ranging from a WSQ Certificate up to a WSQ Graduate Diploma. These qualifications are portable between different companies increasing worker mobility across companies and industries.

As training programs in the manufacturing sector can be more informal and vary significantly between companies, a national system allows for increased standardisation and ensures a certain level of competency is achieved across industries. The high level of transparency around competencies achieved with each course assures employers of staff being trained with required skills and reduces the need to develop training programs from scratch. Also as companies identify gaps in the system, they can request for a new WSQ or module to be created. Workers benefit from the training programs by being able to demonstrate mastery and move up to higher skilled roles within their organisations, to other companies or industries.

The training programs are subsidised by the government, and both employers and employees contribute towards course fees, depending on who initiated the training. This allows individuals who wish to pursue training in a new field the flexibility to do so, while also allowing employers to conduct basic training for their employees.

The program has been successful with high satisfaction levels reported. A 2015 survey by the Workforce Development Authority found that 97% of companies would continue to send their employees for WSQ training and 88.2% of trainees surveyed wanted to continue to take up other WSQ training.

Source: Skills Future, Workforce Singapore

Conclusion

Canada has a highly developed mixed economy with manufacturing as a key contributor to the country's revenue, exports and employment. The sector has been recovering and is likely to continue the growth supported by a well-educated workforce, strong government support and positive business environment. Ontario and Quebec are the engines for growth, production and exports and likely to be the provinces of focus in shaping the future of the manufacturing sector.

The Fourth Industrial Revolution has created new critical success factors in the manufacturing sector, and the potential implications for Canadian manufacturing are significant, particularly in terms of improving productivity to drive growth. Canadian manufacturing companies, particularly SMEs, will need to be supported on their digitisation journey in order for them to fully capitalise on the potential of Industry 4.0 tools.

The aerospace hub in Quebec has been a bright spot in Canada's manufacturing outlook and serves as a significant player in the global aeronautics value chain, particularly through its exports to the United States.

However, this has exposed the industry to significant trade risk with the ongoing negotiation of NAFTA. Therefore, it is crucial for Canada to develop new partnerships and expand into growing markets. Canada's leadership should also be reinforced through continuous technological development and innovation to capitalise on the emerging trends in the sector.

In addition, the Canadian manufacturing sector also needs to further develop the workforce to create sustainable talent pipelines for the changing demand through trainings and lifelong learning. It is also essential to attract relatively underrepresented groups such as women and immigrants into the manufacturing scene in order to bridge the skill gaps and grow the workforce base.

Overall, the manufacturing outlook is positive but the sector must take crucial steps and adapt to seize upon shifting opportunities. The ability of Canada's manufacturing sector to realize its bold Industrie 2030 goal is dependent on the adoption of new technologies and the ability to execute strategic plans. To achieve the next stage of development, both public and private stakeholders need to collaborate and commit to the objectives and actionable plans.

"Canada's SMEs and large industrial companies – in aerospace, forestry, transportation, and others – need to be innovative and grab the opportunity offered by Industry 4.0. This will need new research on products and systems, adoption of new manufacturing and control techniques, and development of versatile and tech-savvy skills. Connecting technology, manufacturing, and engineering with business awareness can make manufacturing aspirational again."

Anil Khurana
GMIS Organizing Committee
PwC Partner, US & ME, and Advisor

"How this nation with a manufacturing heartbeat realises its vision is set to be determined by its ability to enable and encourage the adoption of Industry 4.0 technologies, expand and diversify its export market, and nurture a workforce drawn from all sectors of society and equipped to meet the demands of industry in a time of both revolution and evolution."

Badr Al-Olama
Head of GMIS Organising Committee,

Authors & Contacts

Dr. Anil Khurana
Committee Member, Global Manufacturing & Industrialisation Summit,
Partner, Strategy & Innovation, PwC Middle East and US,
ME lead – Consumer & Industrial Products & Services

T: +971 50 883 6369
E: anil.khurana@pwc.com

Badr Al-Olama
Head of GMIS Organizing Committee

E: info@gmisummit.com

Mohammad Shaban
Director of Strategy
Global Manufacturing & Industrialisation Summit (GMIS)

T: +971 55 900 8363
E: mohammed@gmisummit.com

David Wijeratne
Partner, Growth Markets Centre Leader, PwC

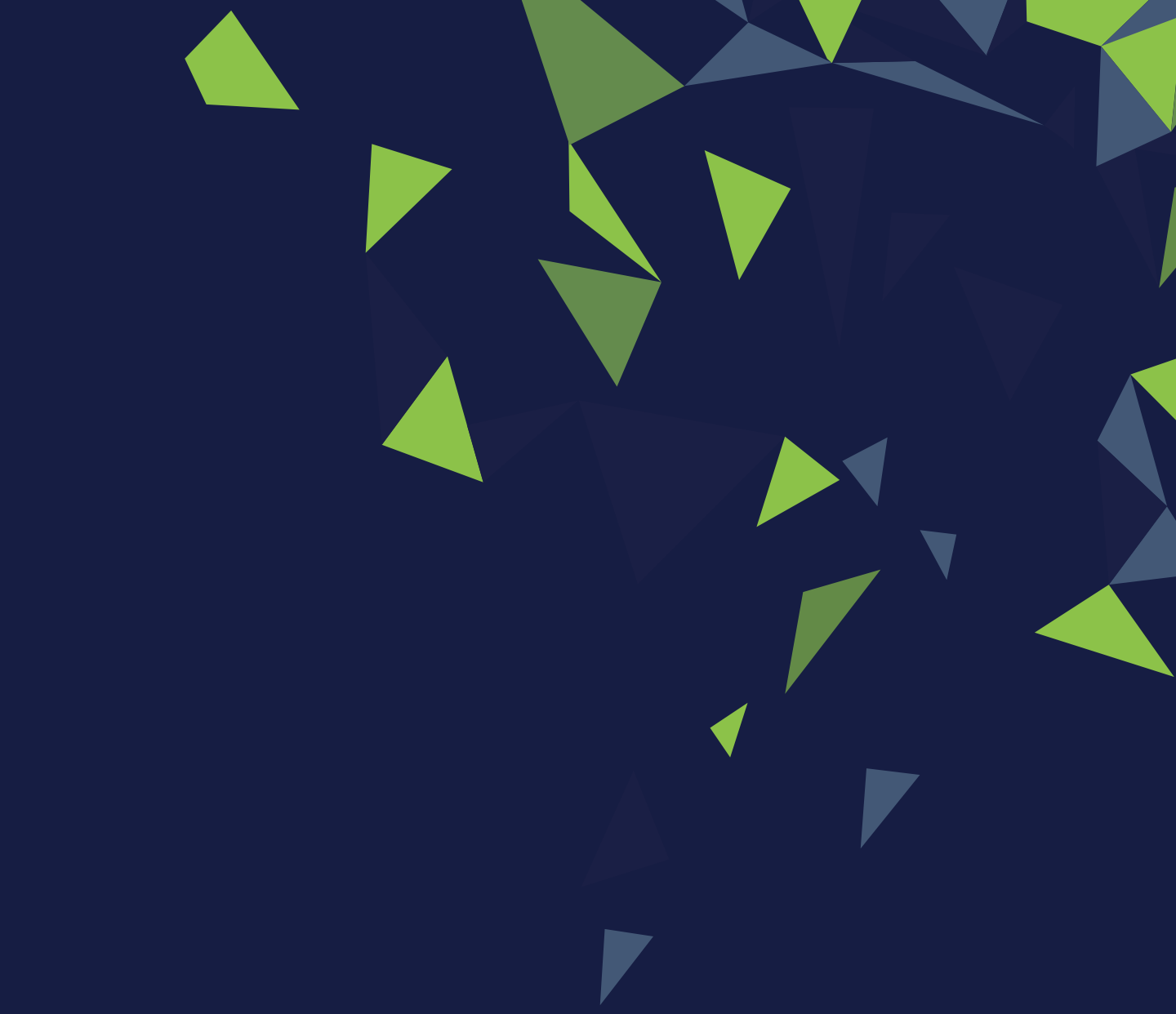
T:+65 6236 5278
E: david.wijeratne@sg.pwc.com

Acknowledgements

- Sidharta Sircar, Director, Growth Markets Centre, PwC
- Jan Pasemann, Growth Markets Centre – EMEA, PwC
- Stella Lau, Senior Manager, Growth Markets Centre, PwC
- Aparna Chandrasekar, Growth Markets Centre, PwC
- Yamei Wang, Growth Markets Centre, PwC
- Anishta Lakhani, PwC Middle East

Notes

1. BMI Research, Canada Country Risk Report, Q2 2018
2. Canadian Foundation for Economic Education, “The Canadian Economy: The Big Picture”
3. Statistics Canada, Manufacturing sales, by province and territory, 2017
4. Statistics Canada, Unemployment rate by province, January 2018
5. Institute for Competitiveness and Prosperity, Five things to know about Ontario’s manufacturing exports, 18 October 2017
6. Invest in Ontario, Ontario, Canada a ‘top 3 destination’ for capital investment
7. Conference Board of Canada, Provincial Outlook Economic Forecast, Autumn 2017
8. Montreal Gazette, “Quebec exports expected to increase 7% this year and next, despite U.S. trade uncertainty”, 24 November 2017
9. Montreal International, “2016: a record year with 1.35 billion dollars in foreign direct investment”, 19 April 2017
10. Conference Board of Canada, Provincial Outlook Economic Forecast, Autumn 2017
11. BMI Research, Canada Forecast 2017
12. UN Comtrade, International Trade Statistics Database, 2016
13. Statistics Canada, Industrial Contributions to Research and Development Spending in Canada, 2017
14. Statistics Canada, Employment by industry, 2018
15. CME-MEC, Untapped Potential: Attracting and engaging women in Canadian manufacturing, 2017
16. BMI Research, Ontario Forecast 2017
17. Ontario Ministry of International Trade, Ontario Trade Fact Sheet, 2017
18. Invest in Ontario, Automotive, 2018
19. Innovation, Science and Economic Development Canada, State Of Canada’s Aerospace Industry, 2016
20. Government of Canada, Achieving A Sustainable Future: A Federal Sustainable Development Strategy for Canada 2016-2019
21. Brookings Institute, Who And What Gets Left Behind? Assessing Canada’s Domestic Status On The Sustainable Development Goals, 2017
22. Innovation, Science and Economic Development Canada, Establishments by employment type and province/territory, 2016
23. Innovation, Science and Economic Development Canada, Advanced Manufacturing Supercluster
24. National Research Council Canada, NRC capabilities in advanced manufacturing
25. Business Development Bank Canada, Industry 4.0: The New Industrial Revolution, May 2017
26. CME-MEC, Accelerating Adoption of Advanced Manufacturing Technologies, 2016
27. Government of Canada, Key Small Business Statistics, June 2016
28. OECD Economic Surveys Canada, June 2016
29. Invest in Ontario, Putting artificial intelligence to work in manufacturing
30. Aerospace Industries Association of Canada, State of Canada’s Aerospace Industry, 2017
31. International Trade Administration, Canada-Civil Aviation
32. Nasdaq, “Spotlight: Bombardier on The Right Track”, 27 March 2018
33. Reuters, “China to spend over $1 trillion on planes over next 20 years: Boeing”, 6 September 2017
34. NATO, Defence Expenditure of NATO Countries (2010-2017), 29 June 2017
35. Reuters, “Boeing signs deal to sell 300 plans worth $37 billion to China”, 9 November 2017
36. Aerospace Industries Association of Canada, Boeing Canada Operations
37. European Commission, EU-Canada trade agreement enters into force, 20 September 2017
38. Research Nester, Drone Market: Global Demand, Growth Analysis & Opportunity Outlook 2023, 2018
39. PwC, The new hire: How a new generation of robots is transforming manufacturing, September 2014
40. CME-MEC, Building a Strong and Skilled Workforce for Growth, 2016
41. CME/ CSTEC, The Future of the Manufacturing Labour Force in Canada, January 2017
42. Statistics Canada, Immigration and Diversity: Population Projections for Canada and its Regions, 2011 to 2036, 25 January 2017
43. Statistics Canada, Job-related training of immigrants, 30 August 2011
44. Mosaic, Refugee Training and Employment Program



Uniting the world in shaping the future of manufacturing is the goal of the Global Manufacturing & Industrialisation Summit (GMIS). A unique and unprecedented cross-industry forum, we bring together governments, the business world, and civil society to create a roadmap of the development of a sector that accounts for million jobs, 17% of global GDP, and 84% of world trade exports – ensuring its evolution mirrors the way the world is changing and supports progress toward the UN Sustainable Development Goals.

A joint initiative by the United Arab Emirates and the United Nations Industrial Development Organization, GMIS – as a platform for leaders to transform manufacturing, a builder of cross-sectoral partnerships, and a knowledge-base that identifies opportunities for the sector to generate universal benefit – is committed to placing manufacturing at the heart of economic regeneration, policymaking, international collaboration, and contribution to global good. Find out more about the GMIS mission, and how you can be part of it, at www.gmisummit.com

At PwC, our purpose is to build trust in society and solve important problems. We're a network of firms in 157 countries with more than 208,000 people who are committed to delivering quality in assurance, advisory and tax services. Find out more and tell us what matters to you by visiting us at www.pwc.com. Established in the Middle East for 40 years, PwC Middle East has firms in Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Oman, the Palestinian territories, Qatar, Saudi Arabia and the United Arab Emirates, with around 4,000 people. (www.pwc.com/me).