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The March of the Robots

Policy Brief

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Introduction

Manufacturers have long understood the benefits of robotic automation—increased production speeds, higher rates of throughput and improved consistency and quality. With robots, manufacturers are able to create leaner and more efficient production operations, reduce costs and enhance their competitiveness.

Today, robots are used in a wide set of applications and across many industries by businesses of all sizes—in warehouses and distribution centers, in hospitals and in schools, and in construction, mining, agriculture, transportation, defence and aerospace. Falling robot prices combined with ever-increasing robot performance have been the impetus behind the continued increase in investment in robotics technology.

The Canadian Chamber is committed to fostering a strong, competitive and profitable economic environment that benefits all Canadians. This paper is one of a series of independent research reports covering key public policy issues facing Canada today.

We hope this analysis will raise public understanding and help decision-makers make informed choices. The papers are not designed to recommend specific policy solutions, but to stimulate public discussion and debate about the nation's challenges.

South Korea, Japan and Germany have the most industrial robots in use per employee. North America lags, but the adoption rate of robots is rising. In China, the dramatic increase in wages and a shortage of labour have turned the country into the world's fastest growing market for robots.

The global economy and the workplace are being reshaped by changes far greater in speed and scale than we have witnessed before.

- Workers are competing not only with workers in other countries, but increasingly with intelligent machines.
- Cheaper and more user-friendly robots are enabling North American companies to bring back at least some of the production (and jobs) they had outsourced to low-wage countries.
- Out-of-the box robots are helping small- and medium-sized businesses compete in the global marketplace.
- The rapid deployment of robots and automated processes in Chinese factories are displacing jobs in China that were created as a result of outsourcing from industrialized countries.
- China will soon be producing higher quality and higher value-added products, posing a growing challenge for North American, European and Japanese businesses that are not used to competing with Chinese firms in the higher-end market segment.
- Technology-driven change is impacting multiple businesses and industries simultaneously, and like never before, transforming the future and nature of work.

Industrial Robots Play an Increasing Role in Modern Production and Assembly

Japan, China, the United States, South Korea and Germany accounted for 72.1 per cent of industrial robot sales in 2012. Roughly 26,270 robots were purchased in North America (22,414 in the United States, 1,749 in Canada and 2,106 in Mexico)—a new high. Japan accounted for 18.0 per cent of total sales, North America 16.5 per cent, China 14.4 per cent, South Korea 12.2 per cent and Germany 11.0 per cent.[1]

The automotive industry is the most important customer of industrial robots, followed by the electrical and electronics, rubber and plastics, metal products, communications, food and beverage, and industrial machinery industries.

The International Federation of Robotics estimates that approximately 2.5 million industrial robots have been sold worldwide since they were first introduced in the 1960s. Many of the early robots have been taken out of service (the average service life of an industrial robot is about 15 years) resulting in a worldwide stock of operational industrial robots of roughly 1.5 million at the end of 2012. The worldwide market value for robotic systems was estimated to be $26 billion.[2]

Japan established itself as a world leader in automation in the 1970s and has the highest operational stock of industrial robots in the world, accounting for 25.0 per cent of the total. North America as whole has 16.0 per cent, Germany 13.1 per cent, South Korea 11.2 per cent and China 7.8 per cent.

The potential for robot installations in the industrial sector remains high in many countries. In 2012, there were about 58 industrial robots in operation per 10,000 employees in the manufacturing industry globally. The average robot density in Korea was about 400 robots per 10,000 employees, in Japan 332, and in Germany 273. In Canada and the United States, the number stood at 103 and 145, respectively.[3] The United States and Canada ranked eighth and 14th, respectively, in the world in terms of the number of robots in use per 10,000 persons employed in the manufacturing industry (in fourth and sixth place, respectively, among G7 countries).

1 International Federation of Robotics. "World Robotics 2013 - Industrial Robots." September 18, 2013.

2 Ibid.

3 Ibid.

China had only 23 industrial robots per 10,000 employees in manufacturing, well below the global average, but that is about to change. Growing labour shortages, the dramatic increase in wages and an increasing unwillingness among the country's youth to perform manual labour is fuelling a boom in automation. One Chinese consumer electronics manufacturer, Foxconn, has announced that it will soon deploy one million robots.

The International Federation of Robotics projects industrial robot sales in China will jump by 65 per cent over the 2012 to 2016 period. Orders are being placed by firms in industries such as automotive, food and beverage, machine tools, electronics, plastics, moulding, transportation, metal processing, composite materials and die-casting.[4] By 2016, China is projected to become the world's biggest purchaser of robots. It is all part the Chinese government's strategy to shift production away from low-end manufacturing to higher value-added production to help sustain wages and spending vital to attaining developed economy status. In the coming years, it is likely that advanced economies will be competing with Chinese firms in the higher-end market segment.

Over the same time period (2012-2016), sales of industrial robots are projected to rise 18.0 per cent in North America and 11.6 per cent in Japan. Sales are expected to remain relatively flat in South Korea and Germany.

The projected growth of industrial robot installations globally "is based on huge potentials of further penetration of the industrial segments like electronics or food and on the ongoing industrialization of the emerging countries. But there are even additional growth potentials in the future based on breathtaking advanced and innovative technological developments… These technologies are opening doors to completely new applications for robots. Impressive for me are the developments regarding human-robot cooperation and opportunities that are provided in new fields of automation, especially in areas where no robots are currently used," commented Dr. Andreas Bauer, Chairman of the International Federation of Robotics' Industrial Robot Suppliers Group.[5]

4 Ruan, Victoria. "Robots on the Rise in China." *South China Morning Post*. May 31, 2013.

5 International Federation of Robotics. "The Robotics Industry is Looking Into a Brighter Future." *Press Release*. September 18, 2013.

Demand for Service Robots Is Rising Rapidly

Robots are also taking their place in the services sector. Since 1998, more than 126,000 service robots for professional use have been sold globally.

Service robots in defence applications accounted for about 40 per cent of the total number of service robots sold in 2012. Field robots (like the milking robots used in agriculture) accounted for 33.0 per cent of sales, while medical robots and logistic systems (for example, automated guided vehicles) accounted for 8.0 and 9.0 per cent, respectively. Other professional robots in demand include construction and demolition systems, inspection and maintenance systems, rescue and security robots, and underwater systems.[6]

The International Federation of Robotics projects that approximately 95,000 new service robots for professional use will be sold globally over the 2013-2016 period with a market value of US$17.1 billion. Medical robots as well as logistic systems have considerable growth potential.[7]

6 International Federation of Robotics. "World Robotics 2013 - Service Robots." September 18, 2013.

7 Ibid.

Robots Are Redefining Industry

When we think of robots, we tend to think of them working in car plants bolted to the factory floor performing routine, repetitive tasks like drilling, welding, stamping, spray painting and assembly, often in isolation to ensure human safety. Now, more sophisticated robots are performing routine and non-routine tasks in a wide variety of industries. They are designed with advanced sensors, powerful computing capabilities, electronics, computer vision, robotic hardware and algorithms as well as networking and high precision GPS localization technologies. The new generation of robots has greater mobility, dexterity, flexibility and adaptability.

Below are some examples of how robots are redefining industry.

Health care

- Robots featuring advanced sensors and motion detectors and powerful microprocessors and voice activation autonomously navigate hospitals corridors transporting food trays, medication, medical charts, linens, laundry and trash. In the next few years, thousands of service robots are expected to be deployed in the health care sector to reduce cost pressures and address labour shortages.[8]
- Surgeons sitting in a console with a monitor can direct the movements of robot-assisted surgical instruments and perform minimally-invasive surgery.
- Human-sized telepresence robots allow doctors to remotely interact with hospital patients.

Construction

- Robots are gradually assuming a range of building-related tasks. They can be deployed in demolition work, and they can conduct inspections of buildings, bridges and other structures in place of tethered construction workers. They can sort through construction waste and find recyclable material and deposit it in appropriate bins. They can efficiently remove asbestos, paint walls, finish concrete floors and weld steel frames.[9]
- Researchers are investigating the commercialization of robots that can read an architect's drawings and build a house using 3D printing technology. They are capable of applying successive layers of concrete, constructing walls and domed roofs.[10]

8 Hay, Timothy. "The Robots are Coming to Hospitals." *The Wall Street Journal*. March 15, 2012.

9 Katz Ferraro McMurtry P.C. "Robotics: Transforming the Construction Industry." *Structure – Winter 2013*.

10 Ibid.

Energy

- Robots are being developed to install and maintain large-scale solar farms. At present, this is an expensive and time consuming process.[11]

- Robots can scale wind turbines and inspect them, resulting in faster diagnosis and repair and less downtime. They can operate year-round in all types of weather conditions.[12]

- Robots armed with high-definition cameras, super-sensitive sensors and a laser can probe and inspect gas transmission pipelines for dents, cracks or corrosion without having to take the line out of service for inspections.[13]

Mining

- In Australia's outback, mining companies are deploying driverless locomotives and trucks to haul iron ore to help plug labour shortages and rein in costs (train drivers earn about $240,000 per year while truck drivers are paid well over $150,000).[14]

Agriculture and food processing

- Researchers are testing a robot that can thin a field of lettuce in the time it takes 20 workers to do the job by hand. It could supplement an unstable agricultural workforce, increase quality and yield a more consistent product. The robot uses video cameras and visual-recognition software to identify which lettuce plants to eliminate. Until now, fruit and vegetable production destined for the fresh food market has resisted mechanization because it is sensitive to bruising.[15] Researchers have also developed systems that use robotics and vision technology to harvest ripe fruits and vegetables without damaging leaves.[16]

- Larger food processing companies are embracing automation and robotics to improve productivity, lower worker injuries and improve food safety. Robotics with vision-guided capabilities are capable of assessing the most efficient way to process food, pick out ingredients that do not meet quality standards and detect good from rotten produce.[17]

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11 Cardwell, Diane. "A Staff of Robots Can Clean and Install Solar Panels." *The New York Times*. October 14, 2013.

12 GE. "GE Advances Wind Turbine Inspection Through Successful Robotic Trial." *Press Release*. June 13, 2012.

13 Pacific Gas and Electric Company. "PG&E's Tests New In-Line Inspection Technology That Inspects Once Unpiggable Pipelines." *News Release*. October 15, 2013.

14 Behrmann, Elizabeth. "Rio Replacing Train Drivers Paid Like U.S. Surgeons: Commodities." *Bloomberg News*. October 3, 2013.

15 Wozniacka, Gosia and Terence Chea. "Agricultural Robots Could Revolutionize Fresh-market Fruit, Veggie Production, Ease Labour Woes." *The Associated Press*. July 14, 2013.

16 Goldman, Corey. "Canadian Food Processors Beginning to Catch on to Benefits of Automation." *Financial Post*. June 4, 2013.

17 Ibid.

Defence

- The defence industry already deploys unmanned aerial and ground vehicles (e.g. bomb fighting robots and demining robots). More advanced humanoid robots are being developed that can cross rough terrain and perform rescue operations.[18]

Transportation

- Google has developed a self-driving "robot" car. Car manufacturers are plotting their own driverless cars. Google is considering using its vehicles to create an autonomous 'robo-taxi' service.[19] Autonomous vehicle navigation may eventually be expanded to buses, agricultural vehicles, forklifts and cargo-handling vehicles, transforming transportation as we know it. Regulators will need to come up with the necessary rules and standards.

Warehousing and distribution

- Hundreds of autonomous mobile robots can be found in warehouses locating items in a customer's order, bringing product shelves to warehouse workers and helping get packed boxes to the final loading dock, requiring fewer workers to walk up and down the aisles.[20]

Other applications

- A burger-flipping robot can dispense 360 sizzling burgers per hour, potentially saving restaurants up to $135,000 in annual labour costs.[21]
- Hollywood's latest blockbuster movie, *Gravity*, was filmed by robots.[22]
- Robots can conduct job interviews.[23]
- Robots are teaching everything from math to vocabulary to nutrition inside classrooms.[24]

18 BBC News. "Pentagon-funded Atlas Robot Refuses to be Knocked Over." October 7, 2013.

19 Vincent, James. "Google Considering Turning Self-driving Cars into a 'Robo-Taxi' Service." *The Independent.* August 26, 2013.

20 Letzing, John. "Amazon Adds That Robotic Touch." *The Wall Street Journal*. March 20, 2012.

21 Sorensen, Chris. "Robots: Job Terminators." *Maclean's*. October 6, 2013.

22 Byrne, Ciara. "How robots filmed Hollywood's latest blockbuster, 'Gravity'." *Venture Beat*. October 7, 2013.

23 Nickless, Rachel. "Interviewed for a Job by Sophie the Robot." *The Australian Financial Review*. April 10, 2013

24 Hollander, Sophia. When a Teacher Is 2 Feet Tall." *The Wall Street Journal*. April 11, 2013.

Meet Baxter

Baxter is Rethink Robotics' flagship robot. Baxter does not require safety enclosures or special equipment. He is fully mobile and works safely alongside people. Baxter is particularly attractive to small- and medium-sized businesses because he can be put to work right out of the box with minimum setup. He requires no specialized programming or costly engineering work. He can be taught new tasks in as little as 10 minutes. A human worker simply guides the robot's arms and manipulator fingers through the motions that will be needed for the task. Baxter then memorizes these patterns and can communicate that he has understood its new instructions.

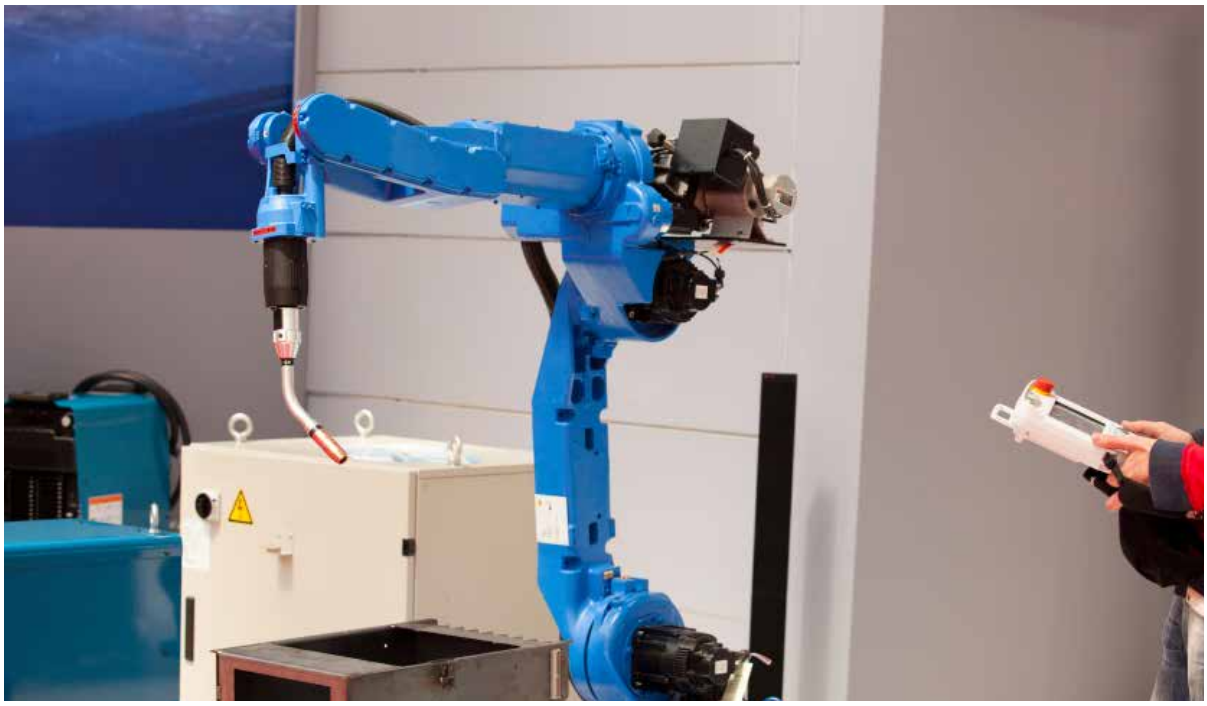
It is estimated that there are about 300,000 small-to-medium sized manufacturers in the United States that Baxter would be perfect for—especially in plastics, metal parts manufacturing and consumer goods packaging.[25]

Baxter costs US$22,000 (compared to US$50,000 to US$200,000 for a typical industrial robot) and $3 an hour to operate. He enabled businesses to compete with low-cost labour in Asia.

"Baxter is inexpensive enough to do the kind of rote tasks that many firms are paying workers in developing countries to do. This way, manufacturers can keep their factories at home and stay competitive on price."[26]

Economist Paul Krugman agrees. He contends "robots mean that labor costs don't matter much, so you might as well locate in advanced countries with large markets and good infrastructure."[27]

Breakthroughs in robotics, rising wages in Asia, lower energy costs as a result of the shale gas revolution and higher transportation costs have made it more attractive for businesses to reshore manufacturing to North America.



25 Briody, Blaire. "Welcome to the 'Jobless' U.S. Manufacturing Boom." *The Fiscal Times*. March 19, 2013

26 Matthews, Christopher. "Can Robots Bring Manufacturing Jobs Back to the U.S.?" *Time*. September 27, 2012.

27 Krugman, Paul. "Rise of the Robots." *The New York Times*. December 8, 20912.

And What About the Growing Presence of Robots in the Workplace?

Historically, when new technologies have come along, jobs have been lost, and jobs have been created. The mechanization of farming in the early 20th century, for example, eliminated all but a fraction of farm-related jobs.[28] Yet no one could foresee that over the next century new jobs would be created in factories (including in those producing mechanical harvesters and many other agricultural machinery), the automotive industry, in health care, finance, information technology, consumer electronics and hospitality that would employ far more workers than agriculture. Meanwhile, farms have become far more productive, producing higher incomes.

Technological progress enables output to increase over time, quality to improve and prices to come down to the benefit of consumers. Greater competiveness results in increased sales of goods and services, leading to more jobs and higher paying jobs. The ability to produce more enables businesses to enter new markets domestically and internationally, which further increases the overall demand for labour.

A growing number of people are now convinced that this time it is different—technological change is progressing so rapidly that jobs are being automated away in greater numbers than new ones are created.[29] This is because machines are now demonstrating skills they never have had before. Moreover, this is occurring in multiple businesses and industries simultaneously. Displaced workers may not be qualified to fill the new jobs that are being created (for example, in robotics or artificial intelligence). The emergence of new and powerful forms of artificial intelligence may soon put more jobs at risk.

Is any job safe? David Autor, a professor of economics at the Massachusetts Institute of Technology and David Dorn, an assistant professor of economics at the Center for Monetary and Financial Studies in Madrid, argue that individuals that excel in abstract tasks—problem-solving, intuition, persuasion and creativity—have a comparative advantage to robots.[30] These tasks are characteristic of professional, managerial, technical and creative occupations like law, medicine, science, engineering, advertising and design. These jobs typically require a high level of education and analytical capability.

On the other hand, routine task-intensive jobs are susceptible to automation. Robots, for example, can perform repetitive tasks with a high degree of precision and accuracy than humans without getting tired, injured or bored.

Autor and Dorn predict that the middle-skilled jobs that will likely remain beyond the capabilities of robots will be those that combine routine technical tasks with abstract and manual tasks in which workers have a comparative advantage—interpersonal interaction, adaptability and problem-solving. In this category fall medical paraprofessionals (for example, radiology technicians and nurse technicians) and numerous jobs in the skilled trades: plumbers, builders,

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28 In 1900, 40 per cent of the United States workforce was in agriculture. By 2000, less than two per cent of America's workforce worked in agriculture.

29 Sorensen, Chris. "Robots: Job Terminators." *Maclean's*. October 6, 2013. See also Brynjolfsson, Erik and Andrew McAfee. *Race Against the Machine*. *e-book*. October 24, 2011.

30 Autor, David H. and David Dorn. "How Technology Wrecks the Middle Class." *The New York Times*. August 24, 2013.

carpenters, electricians, heating, ventilation and air-conditioning installers and automotive technicians. These professions typically require the foundational skills of a high school education with specific vocational training. There will also be job opportunities for people who offer personal training and assistance, like physical therapists, personal trainers, coaches and guides. These workers adeptly combine technical skills with interpersonal interaction (social intelligence), flexibility and adaptability to offer services that are uniquely human.[31]

"Vocational education can prepare students by fostering skills such as problem-solving and communication and by shifting away from the narrow occupational training it currently focuses on—because such training will quickly grow obsolete."[32] For example, "today's car mechanics understand how to fix dents and transmission problems; in the future, they'll need to know as much about self-driving technology. Firefighters today put out flames much as their grandparents did. In a few years, they may be working alongside the Firefighting Robotic Scout, which can drive into burning buildings, detect dangerous gases, find vulnerable people and beam out a sophisticated three-dimensional map. Similar robot helpers are in the works for factory laborers, police officers and health-care aides."[33]

Additionally, apprenticeship training programs offered to young people while in school have proven to be an effective path to a career in the skilled trades. Germany, Austria and Switzerland experienced milder youth unemployment in the global downturn partly because of their strong apprenticeship traditions.

Going forward, a key challenge for policymakers will be how to best structure our education system and reshape our organizations so that everyone has a fair shot at thriving in the labor market of the future.

The need to retrain workers will pose additional changes. Workers will need to be retrained—both to work with the new technologies and to learn new tasks and skills as their jobs evolve.

In Closing

Erik Brynjolfsson and Andrew McAfee sum it up best in their book *Race Against The Machine.*

"Our technologies are racing ahead, but many of our skills and organizations are lagging behind. So it's urgent that we understand these phenomena, discuss their implications and come up with strategies that allow human workers to race ahead with machines instead of racing against them."

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31 Ibid.

32 The Editors. "Will Robots Take All Our Blue-collar Jobs?" *Bloomberg*. August 13, 2013.

33 Ibid.

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