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Robotics Technologies Adoption: Insights from the Survey of Advanced Technology

by **Rim Chatti, Antonio Di Marco** and **Wanling Li**

In an age defined by innovation and technological advancement, robotics stands at the forefront of transformative change. Robotics is a field that involves the design, construction, operation, and use of intelligent robots capable of performing complex tasks, enhancing productivity, and even augmenting human capabilities.

While it is widely acknowledged that robots significantly improve productivity in critical sectors,[1] their impact extends beyond efficiency. Robots are also capable of addressing some of society's most urgent challenges. For instance, they excel in performing tasks in hazardous environments, such as disaster zones or the depths of the sea, all without jeopardizing human lives. Moreover, they are ushering in a transformative era of precision surgeries, diagnostics, and patient care. They also play a pivotal role in the field of space exploration, contributing to our expanding understanding of the universe. Some examples of robots used in space exporation from NASA are Perseverance, Curiosity (both Mars rovers), A-PUFFER (an autonomous pop-up flat folding explorer robot), and BRUIE (a buoyant rover for under ice exploration). The development of rovers with new capabilities is made possible with the advancement of other technologies such as sensors, control systems, and materials science.

Canada has a nascent robotics ecosystem, clustered around nearly 300 companies, with the majority being small and at an early stage of development, that faces challenges in thriving in an environment of limited domestic adoption.[2] In 2023, Canada was ranked 15th among the top 20 countries for industrial robotics adoption by the International Federation of Robotics.[3] This places Canada behind countries like Thailand (14th), Turkey (13th), Spain (12th), Singapore (10th) and Mexico (9th), and highlights that Canada faces a critical obstacle to the long-term development of this ecosystem. In 2019, Canada ranked 12th in robot installations in the manufacturing sector behind the United States (3rd) and Mexico (9th). Adoption of robotics in the Canadian manufacturing sector is mainly driven by the automotive sector. From 2016 to 2019, Canada's robot density (robots installed per 10,000 employees) in the manufacturing sector grew about half as much as the United States in the same time frame. When removing the automotive sector from the analysis, the gap in robot density between Canada and the United States was even larger.[4]

Despite the relatively low adoption rate, Dixon (2020) demonstrated that Canadian firms that embraced robotics technologies increased their productivity and, on average, grew their workforce by nearly 20%.[5] This suggests that robotics adoption could help to address the skilled labour shortage in Canada.

Failure to capitalize on these opportunities can hamper the country's economic potential and place Canadian businesses at a disadvantage in the global marketplace, hindering innovation and job creation. This analysis uses the Survey of Advanced Technology (SAT) to examine and characterize the adoption of robotics technologies, the performance of robotics technologies adopters, the challenges encountered during the adoption process, and the strategies employed to overcome these challenges.

Robotics technologies adoption

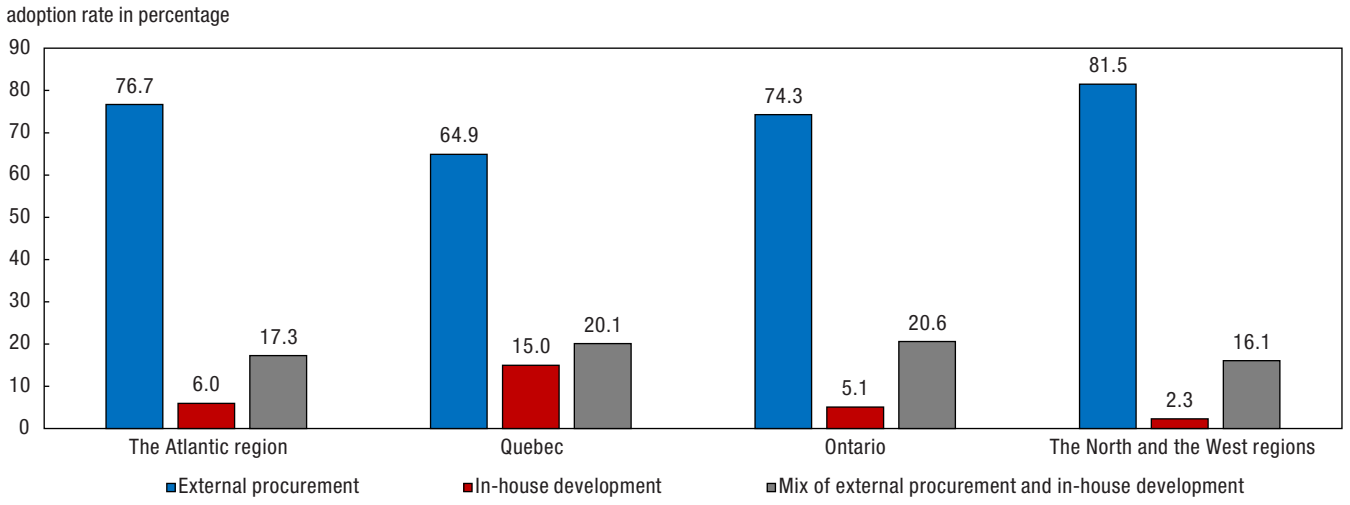
In 2022, 2.0% of Canadian enterprises in industries covered by the SAT adopted robotics technologies.[6] While an additional 0.6% of the enterprises planned to adopt robotics technologies in the upcoming two years, 1.0% acknowledged the technologies were applicable to their business but they did not plan to introduce them and 94.7% reported that the technologies were not relevant to their business. This means that a small fraction of the Canadian economy has used robotics or sees the potential in robotics.

1. OECD Science, Technology and Innovation Outlook (2021) : Times of Crisis and Opportunity: 6. Why accelerate the development and deployment of robots.
2. Canadian Robotics Council (2023) What We Heard Report, 2022 Symposium.
3. International Federation of Robotics (2022) World Robotics 2022: Industrial Robots. International Federation of Robotics (2023) World Robotics 2023: Industrial robots.
4. NGen Canada (2019): Canada's Automation and Robotics Landscape : Automation-and-robotics-NGen-Report.pdf.
5. Jay Dixon (2020) The Effect of Robots on Firm Performance and Employment, Statistics Canada 11-626-X No. 126.
6. In the Survey of Advanced Technology, robotics technologies are defined as robots with image recognition systems, artificial Intelligence (AI) technologies enabaling physical movement, AI technologies for automation of processing and fabrication processes and automated guided vehicles, and other AI systems.

Among the 2% of enterprises that adopted robotics technologies,[7] 73.0% exclusively sourced them from external providers, while 7.4% opted for in-house development for own use in their operations and the remaining 19.6% utilized a combination of external procurement and in-house development.

Ontario had the highest proportion of enterprises that adopted robotics technologies (3.0%), followed by Québec (2.2%), the Atlantic region (1.4%)[8] and the North and the West regions (0.9%)[9] which recorded the highest proportion of enterprises (81.5%) that acquired robotics technologies exclusively from external sources and the lowest proportion of enterprises (2.3%) that opted for internal development. Québec, on the other hand, registered the largest proportion of enterprises developing robotics technologies exclusively internally (15.0%), almost three times higher than in Ontario (5.1%) and two and a half times higher than the Atlantic region (6.0%).

Chart 1
Robotics technolgies adoption strategy across regions



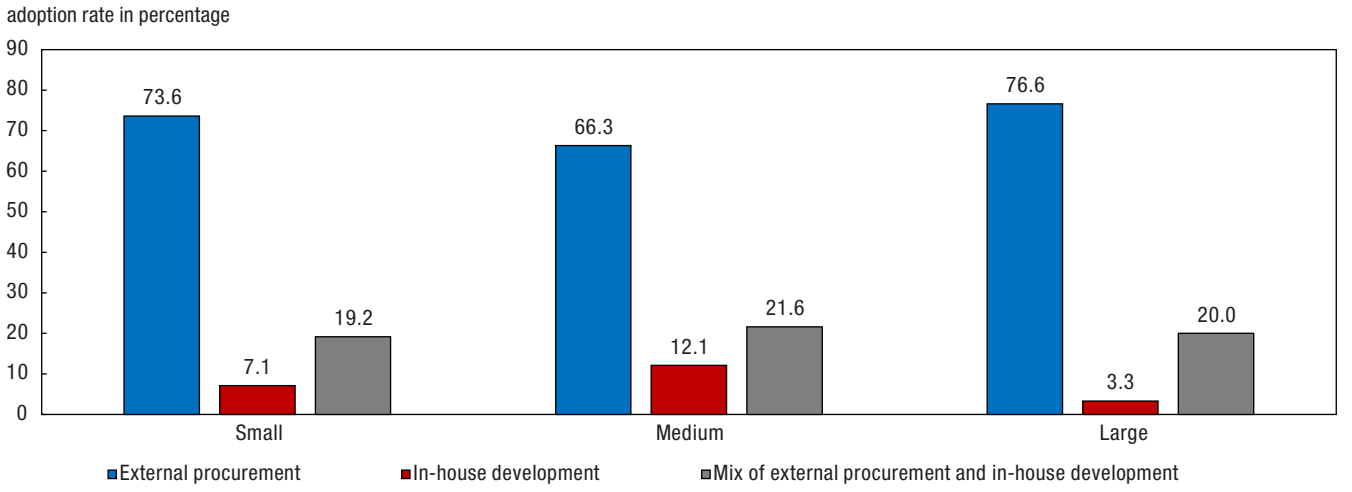
Notes: The bars represent the percentage of enterprises that adopted robotics technologies at any point in time. Adoption is captured either through internal development strategy or external sourcing strategy or a mix of both strategies.
Source: Survey of Advanced Technology, 2022. Custom data.

Large enterprises had the highest robotics technologies adoption rate (9.1%).[10] Their adoption rate was nearly twice that of medium-sized enterprises (5.3%) and six times higher than the rate for small enterprises (1.6%).

Large enterprises (76.6%) were also the most likely to acquire robotics technology from an external source and the least likely to develop robotics in-house exclusively (3.3%). Internally developed own-use robotics was championed by medium-sized enterprises (12.1%), almost two times higher than that of small enterprises (7.1%), and four times higher than that of large enterprises.

7. The adoption rate of robotics technologies is measured by the percentage of enterprises that acquired the technology from external sources at any point in time, or those that developed the technology in-house for own use in operations at any point in time.
8. Atlantic region refers to Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland and Labrador
9. North and West regions refers to the Yukon, Northwest Territories, Nunavut, Manitoba, Saskatchewan, Alberta, and British Columbia
10. Enterprise size groups are defined based on the total number of employees. Small enterprises encompass a range of 10 to 99 employees; medium-sized entreprises range from 100 to 249 employees and large enterprises consist of those with more than 250 employees.

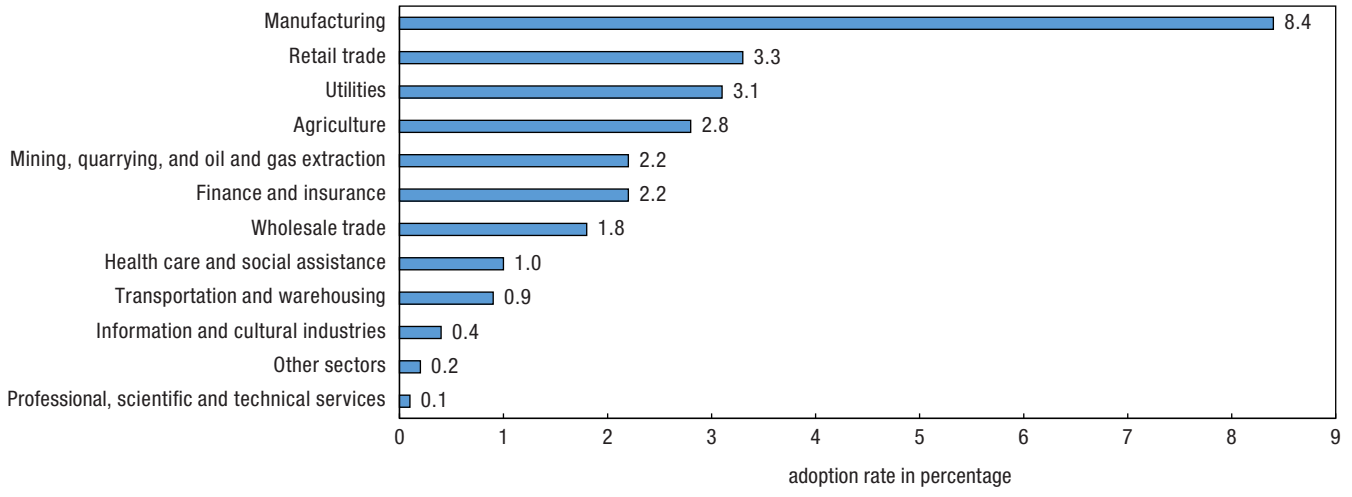
Chart 2
Robotics technologies adoption strategy by enterprise size



Notes: i. The bars represent the percentage of enterprises that adopted robotics technologies at any point in time. Adoption is captured either through internal development strategy or external sourcing strategy or a mix of both strategies.
ii. In the Survey of Advanced Technology 2022, enterprise size is determined by the total number of employees. Small enterprises employ from 10 to 99 employees, medium sized enterprises from 100 to 249 employees and large enterprises have more than 250 employees.
Source: Survey of Advanced Technology, 2022. Custom data.

Manufacturers were the biggest users of robotics technologies (8.4%), with an adoption rate almost 3 times higher than the next leading industry sector. Retail trade (3.3%) and utilities (3.1%) followed with a distant 2nd and 3rd highest adoption rates. In comparison, professional, scientific and technical services recorded the lowest adoption rate (0.1%).

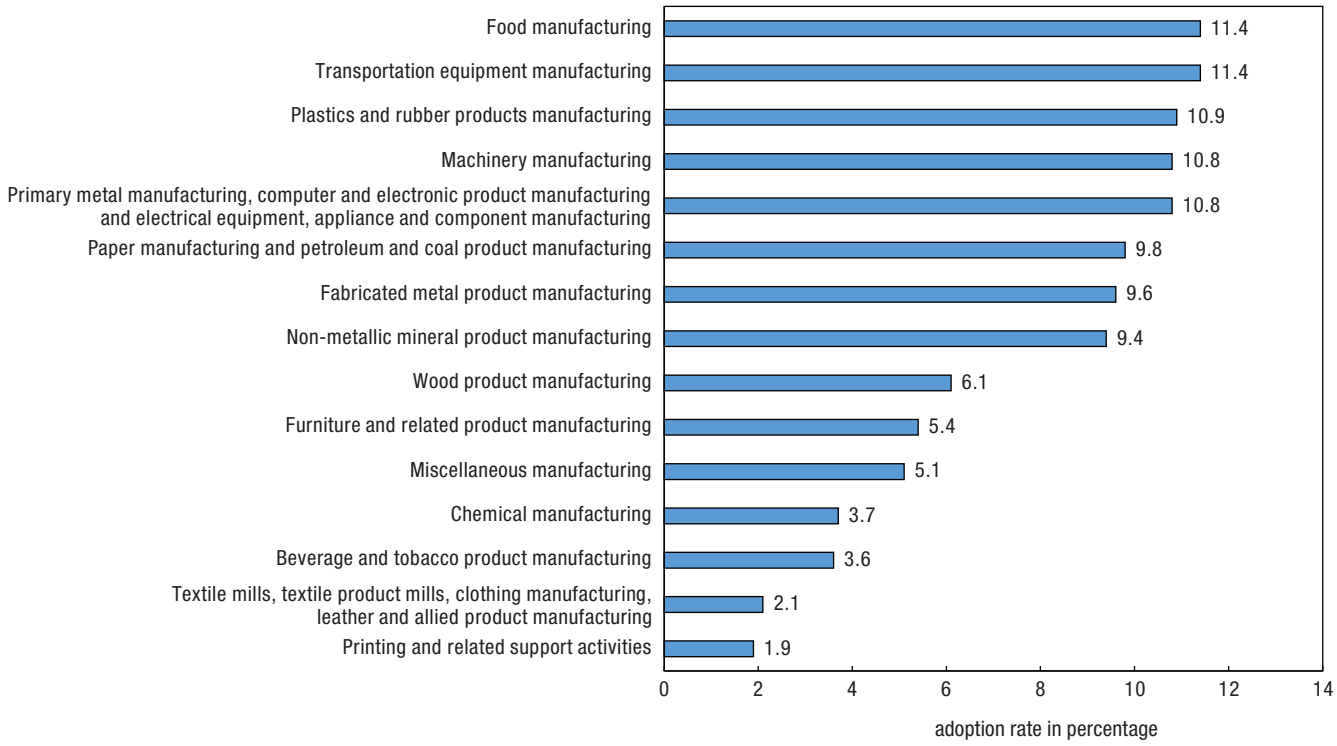
Chart 3
Rate of adoption of robotics technologies across sectors



Notes: The bars represent the percentage of enterprises that adopted robotics technologies at any point in time. Adoption is captured either through internal development or external sourcing or both.
Source: Survey of Advanced Technology, 2022. Custom data.

Within the manufacturing sector, robotics technologies adoption was most prevalent in food manufacturing (11.4%), transportation equipment manufacturing, including motor vehicles manufacturing (11.4%), plastics and rubber products manufacturing (10.9%) and machinery manufacturing (10.8%).

Chart 4
Rate of adoption of robotics technologies within the manufacturing sector

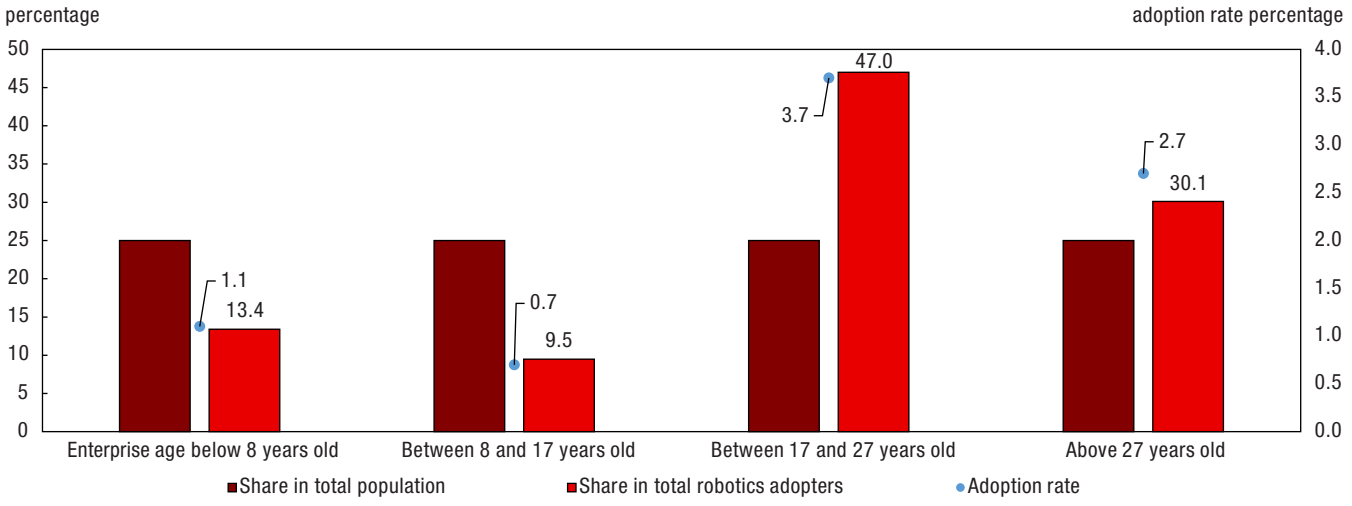


Notes: The bars represent the percentage of enterprises within the manufacturing sector that adopted robotics technologies at any point in time. Adoption is captured either through internal development for own use in production or external sourcing or both.
Source: Survey of Advanced Technology, 2022. Custom data.

The adoption rate of robotics technologies differed by age of business. Businesses over 17 years old were more likely to adopt robotics technologies compared to those aged less than 17 years old which had an adoption rate below the national average of 2.0%.[11] The adoption rate peaked at 3.7% for enterprises aged between 17 and 27 years old, and came in at 2.7% for enterprises older than 27 years old. These two age groups, while constituting half of all enterprises, accounted for 77.1% of the adopters. Specifically, 47.0% of adopters belonged to enterprises aged between 17 and 27 years old, while 30.1% came from enterprises older than 27 years old.

11. The enterprises were split into four age groups, where each group accounted for 25% of the extrapolated population; referred to in the chart as the share in total population.

Chart 5
Adoption of robotics technologies by enterprise age group



Notes: The enterprises were split into four age groups, where each group accounted for 25% of the extrapolated population; referred to in the chart as the share in total population. The blue scattered dots represent the adoption rate within each enterprise age group. The light red bars represent the share of each enterprise age group in total robotics technologies adopters.
Source: Survey of Advanced Technology, 2022. Custom data.

Performance of robotics technologies adopters

Over three-quarters (77.7%) of Robotics adopters were innovative, meaning they introduced a new or improved product onto the market, or they implemented a new or improved business process. This compared to an innovation rate of 42.9% for enterprises that did not adopt robotics technologies.

Higher productivity is also evident with robotics technologies adopters. While constituting 2.0% of the business population, adopters of robotics technologies accounted for 7.5% of total employment and 11.5% of total revenue in the economy.[12] This is more marked the larger the business. Large-sized enterprises adopting robotics technologies accounted for 12.8% of employment and 16.4% of revenue, medium-sized enterprizes accounted for 5.7% of employment and 7.6% of revenue and small-sized businesses' contribution to total employment was 2.2% and to total revenue 2.7%.

Obstacles and disincentives to robotics technologies adoption and measures taken to reduce them

Lack of skills is a significant obstacle in advanced technology adoption. Over three in five (61.7%) businesses that adopted at least one advanced technology reported difficulty recruiting qualified staff as a significant obstacle.

Of the 2.0% of businesses that adopted robotics technologies in the Survey of Advanced Technology, approximately one quarter (25.2%) of businesses reported difficulty recruiting qualified staff as a significant obstacle.[13] While over two fifths (42.0%) of businesses reported offering training as needed to attempt to reduce obstacles to adoption.

A lower proportion of small enterprises took measures to reduce obstacles of adopting robotics technology than large enterprises, despite reporting obstacles to robotics adoption at a similar proportion to large enterprises. Over one in five small and large enterprises reported difficulty recruiting qualified staff (23.1% and 28.8% respectively) while 68.2% of large enterprises offered training as needed to reduce obstacles compared to 34.7% of small enterprises who adopted robotics.

12. Data on employment and revenue at the enterprise level is generated from tax data for reference year 2021.
13. Obstacle significance is rated as 4 or 5 on a 1 to 5 scale, with 1 meaning not significant and 5 being very significant

A higher proportion of enterprises in Atlantic Canada reported significant obstacles to robotics technologies adoption than in other regions in Canada. Atlantic Canada was also more inclined to use measures outside of the most implemented measures to address obstacles. Just over one in five enterprises in Atlantic Canada (21.1%) implemented performance bonuses compared to the other regions where less than one in ten (8.8% in Ontario, 8.3% in the North and West regions, and 6.6% in Quebec) enterprises implemented performance bonuses to reduce obstacles to robotics adoption.

Annex

Table 1
Obstacles and disincentives to robotics technologies adoption

Obstacle	All sizes	Large	Medium	Small
	percent			
Difficulty in recruiting qualified staff	25.2	28.8	42.3	23.1
Low return on investment or long payback period	21.4	22.8	19.7	21.4
Lack of employee training	20.2	25.0	36.1	18.1
Difficulty in accessing financial support	19.6	15.4	19.3	20.0
Difficulty in integrating new advanced technologies with existing systems, standards and processes	19.5	26.4	20.3	18.8
Employees' resistance to change	17.0	18.7	26.4	15.9
Challenges in identifying appropriate technologies	15.2	21.6	18.7	14.3
Difficulty in accessing non-financial support	13.8	14.2	16.5	13.4
Disruption of production for the integration of new technologies	13.5	20.3	24.4	11.8
Determining how new technologies will positively impact the business	13.3	18.2	13.9	12.7
Customer resistance	9.6	6.5	6.5	10.2
Decisions made elsewhere in the organization and not in the enterprise itself	8.3	13.1	8.4	7.9
Ensuring security and privacy of data	7.9	16.0	10.0	6.9
Regulatory constraints or uncertainties	7.7	10.3	8.7	7.4

Note: Numbers in this table represent the percentages of enterprises that rated the obstacle as 4 or 5 on a 1 to 5 scale, with 1 meaning not significant and 5 being very significant.
Source: Survey of Advanced Technology, 2022, Custom tabulation.

Table 2
Obstacles and disincentives to robotics technologies adoption across regions

Obstacle	Atlantic Canada	Québec	Ontario	North and West regions
	percent			
Difficulty in recruiting qualified staff	48.2	41.3	19.5	18.9
Difficulty in integrating new advanced technologies with existing systems, standards and processes	43.1	28.8	12.3	19.8
Lack of employee training	38.4	33.9	18.9	10.2
Low return on investment or long payback period	36.2	30.8	14.8	21.9
Difficulty in accessing financial support	35.6	26.5	13.5	21.2
Disruption of production for the integration of new technologies	34.2	22.0	10.8	8.5
Employees' resistance to change	33.0	28.4	12.2	13.6
Difficulty in accessing non-financial support	31.3	19.7	5.2	18.8
Determining how new technologies will positively impact the business	29.9	22.0	10.3	9.3
Ensuring security and privacy of data	25.6	13.1	6.0	4.6
Challenges in identifying appropriate technologies	22.2	24.3	11.4	13.1
Customer resistance	19.9	16.1	5.3	9.7
Regulatory constraints or uncertainties	15.7	14.9	3.0	8.0
Decisions made elsewhere in the organization and not in the enterprise itself	6.8	10.0	6.0	10.2

Note: Numbers in this table represent the percentages of enterprises that rated the obstacle as 4 or 5 on a 1 to 5 scale, with 1 meaning not significant and 5 being very significant.
Source: Survey of Advanced Technology, 2022, Custom tabulation.

Table 3
Measures taken to reduce obstacles to the adoption of robotics, by enterprise size

Measure	All Sizes	Large	Medium	Small
	percent			
Offer training as needed for the needs of the organization	42.0	68.2	60.4	34.7
No measures were taken	40.6	15.8	18.5	48.3
Calling in consultants or subcontracting for short-term needs	31.5	63.3	46.3	23.9
Improved working conditions	24.7	37.4	28.2	22.1
Collaborating with other companies or non-profit organizations	13.9	17.0	19.8	12.4
College, CEGEP and university recruitment	9.2	20.9	9.2	7.3
Performance bonuses	8.6	14.6	8.9	7.6
Seeking support from professional organizations	6.9	12.3	7.4	6.0
Seeking government support	6.1	5.3	7.4	6.0
Collaborating with colleges, CEGEPs, universities or research institutions	5.5	12.3	16.1	2.5
Collaborating with government research organizations	3.1	2.0	11.5	1.8
Acquiring another Canadian enterprise that had already developed the required advanced technology	1.5	4.3	0.2	1.2
Acquiring another foreign enterprise that had already developed the required advanced technology	0.8	0.9	2.4	0.6

Note: The numbers in the table represent the proportion of enterprises that used the measure to reduce obstacles to adoption of robotics.
Source: Survey of Advanced Technology, 2022. Table 27-10-0393-01.

Table 4
Measures taken to reduce obstacles to the adoption of robotics across regions

Measure	Atlantic Canada	Québec	Ontario	North and West regions
	percent			
Offer training as needed for the needs of the organization	58.1	56.8	36.9	32.9
Calling in consultants or subcontracting for short-term needs	49.0	37.6	24.2	44.9
Improved working conditions	35.2	29.6	23.6	18.1
No measures were taken	26.2	19.3	52.9	33.0
Collaborating with other companies or non-profit organizations	24.9	5.1	11.5	35.9
Performance bonuses	21.1	6.6	8.8	8.3
College, CEGEP and university recruitment	13.1	12.5	9.3	2.1
Seeking government support	12.2	9.4	5.0	3.3
Collaborating with colleges, CEGEPs, universities or research institutions	11.6	3.5	6.7	2.8
Collaborating with government research organizations	6.8	6.4	1.9	0.9
Seeking support from professional organizations	4.3	7.6	5.9	10.4
Acquiring another Canadian enterprise that had already developed the required advanced technology	0.0	0.2	2.1	1.5
Acquiring another foreign enterprise that had already developed the required advanced technology	0.0	1.2	0.9	0.0

Note: The numbers in the table represent the proportion of enterprises that used the measure to reduce obstacles to adoption of robotics technologies.
Source: Survey of Advanced Technology, 2022. Table 27-10-0393-01.