Technology and Automation Adoption Readiness

An evaluation framework for small and medium-sized enterprises in agriculture and food and beverage manufacturing

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About the Canadian Agricultural Human Resource Council
The Canadian Agricultural Human Resource Council (CAHRC) is a national, non-profit organization focused on addressing human resource issues facing agricultural businesses across Canada.

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Introduction

Adopting novel technologies is a key driver of economic growth in every industry across the country. Economic logic and rationale state that companies will adopt technological solutions that improve their productivity and offer a competitive advantage over their competitors. Yet in Canada's agriculture and agri-food sectors[1, i], there are various factors that hold back a business's ability to invest in improving their productivity. These factors vary from structural (such as a lack of rural infrastructure[ii]), to capacity-based (such as a lack of skilled employees who understand tools and fields such as digital marketing[iii]), to challenges that may seem disconnected from technology issues entirely (such as a lack of available maintenance staff to repair mechanical breakdowns).[iv, v] These barriers to investment prevent the adoption of novel technologies, and can even reduce competitiveness and growth for an entire region or sector over the long run if left unaddressed.[vi] In many cases, successfully overcoming these barriers will look different for each organization. Some are starting their technology adoption journey and lack established foundations or expertise around how to integrate technology in the first place. Other organizations are experts whose ambition is only limited by the infrastructure available to them. The best solutions are those that make the most sense given the company's market position and history with adopting "technology solutions."

For these reasons, helping individual businesses in the agriculture and agri-food space, especially small-to-medium sized enterprises (SMEs), improve their readiness to adopt new technologies is a critical priority of various sector groups. For example, automation and technology is one of the five primary focus areas for the Canadian Agricultural Human Resource Council (CAHRC)'s National Workforce Strategic Plan.[vii] This report supports this objective by creating a framework for each SME to identify how ready they are to adopt novel technologies. This framework identifies several major challenges faced by companies at various stages and can offer SMEs the insights needed to understand which next steps make the most sense for them. Beyond this, this report discusses technology adoption challenges in the agriculture and agri-food space more broadly and can be used as a resource for groups interested in helping create a more digitized, automated, and technologically advanced food production and manufacturing sector in Canada.

What is technology adoption, and how ready are Canadian SMEs to adopt new technologies?

Businesses can adopt any range of technologies available to support their operations, from basic hardware solutions to advanced and emerging software tools (Table 1). Typically, hardware and software tools are implemented and used together. For example, a robot is a piece of hardware that is programmed for specific tasks via software. The first step in the technology adoption journey is typically use of "basic" technologies like having an online presence, using social media, e-commerce, electronic invoicing, and so forth.[viii]

[1] The agriculture and agri-food sector includes primary agriculture, food and beverage processing, food retailer and wholesalers, and foodservice providers as part of a whole integrated supply chain.

Table 1. Examples of some of the technologies that SMEs use.[ix, x, xi]

Technology Types	Basic	Advanced	Emerging
Hardware	Desktop and laptop computers, printers, telephony systems	Servers, portable storage devices, video cards, processor upgrades	Automated, connected, and electric vehicles, robots, and drones. Smart sensors
Software	Online presence, social media, e-commerce, communication tools	Cloud services, Customer Relationship Management (CRM) software, cybersecurity, enterprise resource planning	Artificial intelligence, integrated Internet of Things systems, big data analytics

SMEs tend to be slower to adopt advanced technologies like Customer Relationship Management (CRM) software, cybersecurity, and cloud computing than larger firms. Canadian businesses notably lag in implementing CRM software to manage and track external interactions; for instance, only 13% of small enterprises have implemented a CRM.[xii] SMEs are also often slower to adopt cybersecurity measures, tools, and procedures, even though the consequences of inaction can be severe.[xiii] According to the Insurance Bureau of Canada's *2023 Cyber Security Survey*, 60% of small businesses think cybersecurity measures are unnecessary due to their size and 69% said cybersecurity is not a financial priority (even though almost 40% of employees responded that there has been an increase in scam attempts in the past year, and 75% of employees reported having done something that posed a cybersecurity risk).[xiv]

Based on total private sector employment in 2019, SMEs in agriculture, forestry, fishing and hunting accounted for 98.3% of employment in those industries while manufacturing SMEs accounted for 82.7% of employment.[xv,2] Only 19% of Canadian SMEs are considered to be "digitally advanced" whereas more than half of SMEs are conservative, with low digital adoption and low culture of change.[xvi] Canadian SMEs also often lack employees with in-house digital skills to adopt basic solutions.[xvii] Some specific gaps have been identified around the adoption of basic technologies including social media, e-commerce, and strategically using the internet for retail purposes.[xviii]

Data shows that SMEs in agriculture and food and beverage manufacturing also use advanced and emerging technologies[xix, 3] at lower rates than large enterprises (Appendix 1).[xx] For comparison, 41.2% of all surveyed Canadian industries in 2019 of all sizes use advanced technology and 17.3% use emerging technology.[xxi] Of all enterprise sizes in agriculture, forestry, fishing and hunting, 38.5% use advanced

[2] SMEs are defined as companies who have between 1 - 499 employees. Small businesses have 1 - 99 employers, while medium-sized enterprises have between 100 - 499.

[3] Advanced technologies include technologies for Material handling, supply chain or logistics, Design or information control, Processing or fabrication, Business intelligence, as well as Clean technologies, and Security or advanced authentication systems. Emerging technologies include Nanotechnology, Biotechnology, Geomatics or geospatial technologies, Artificial intelligence (AI), Integrated Internet of Things (IoT) systems, and Blockchain technologies.

technology and 16.7% use emerging technology.[xxii] In food manufacturing specifically, while 45.5% of food manufacturers use advanced technologies, only 7.7% use emerging technologies.[xxiii] This shows that these sectors are below average in adopting emerging technologies, even if their uptake of advanced technologies remains roughly average, or even slightly above average.[xxiv]

[*Text box: Examples of advanced technologies in agriculture and agri-food*
The types of advanced technologies used in food production and manufacturing can include:

- Artificial intelligence (AI) and big data;
- Sensors, broadband networks, and other Internet of Things (IoT) technologies;
- GIS, GPS, and aerial images;
- Automated, connected, and electric vehicles, robots, and drones;
- Biotechnology and informatics.[xxv]

Precision agriculture uses many of these technologies, as well as application program interfaces (API) that allow programs from different companies to work together and share data[xxvi] and high-tech farming equipment (tractors, combines, sprayers, and so forth) to gather real-time data on metrics like soil, climate, plants, and livestock. Producers use these tools and data to make decisions around processes such as seeding, spraying, and harvesting.[xxvii, xxviii] Granular data is used to reduce inputs like water and fertilizers, only applying where necessary, with the goal of maximizing output and increasing sustainability.[xxix] Larger farms and younger producers are more likely to adopt and integrate advanced technologies into their regular operations.[xxx]
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Overview of technology adoption trends in agriculture

Since the late 1980s, robotics and automation have been replacing original electrical machines on farms and in food and beverage manufacturing facilities.[xxxi] In the past decade, the "Agriculture 4.0" shift has been widely touted, which is defined by current emerging technologies creating cyber-physical systems that use a mix of hardware and software to complete on-farm activities.[xxxii] These include drones, robots for tasks like fruit-picking, AI-interfaces, and a high number of sensors.[xxxiii]

As noted, basic agricultural technologies have been adopted at significantly higher rates than advanced or emerging technologies.[xxxiv] With the exception of cloud solutions being widely adopted in all agriculture and agri-food sectors (save horticulture), major advanced and emerging technologies like drones, agricultural robots, Internet of Things/ sensors, and artificial intelligence have low adoption rates, despite the enthusiasm for Agriculture 4.0.[xxxv] Within the sector, the lowest digitalization rates were found in fishing and agricultural occupations.[xxxvi] Furthermore, technology adoption throughout Canadian agricultural sub-sectors is not equal. The nature of the work influences the feasibility of technology and automation adoption. Since agricultural activities are highly varied, overall technology adoption and the types of technology used also vary.[xxxvii] For example, it is easy to automate the process of cow milking, but more difficult and costly to automate tasks like fruit picking.[xxxviii] Additionally, there are differences between sub-sectors: crop production in western Canada relies on precision agriculture and machines, but greenhouses and fruit farms still primarily require physical labour.[xxxix] Different sub-

sectors have therefore prioritized different technologies, and are subsequently stronger in those areas than in areas that make less sense for their sector. Naturally, precision agriculture technologies have mostly been adopted by primary producers, and automation has mostly been adopted by manufacturers.[xl] Making the switch to online business operations and sales has been greatest in the agricultural technology and manufacturing sub-sectors, and computers and laptops are often used for farm management purposes.[xli, xlii]

Although technology innovation and adoption in agriculture is projected to be slower than other sectors by about 10-15 years, professionals in agriculture are optimistic about the future, in part due to the increased rate of technology adoption observed in Canada since 2016.[xliii] This acceleration is rapid for certain technologies, as some stakeholders have noted that what used to take 10 years now only takes two years.[xliv] However, it is unclear whether this increased rate is sufficient enough to catch up and meet current needs.[xlv]

Overview of technology adoption trends in food and beverage manufacturing

The current state of technology adoption for food and beverage manufacturing SMEs in Canada is similar to agriculture. In the Canadian agri-food space, the adoption rate of basic technologies is typically quite high, while adoption rates are lower for advanced and emerging technologies.[xlvi] In 2017, the average number of Canadian manufacturing businesses that had implemented digital technologies was 39%, compared to 28% of food and beverage manufacturing businesses having implemented digital technologies.[xlvii] Internationally, most Canadian food manufacturing sub-sectors were found to be lagging behind American and European counterparts.[xlviii]

Technology adoption in this sector is often gradual, with new, fully automated processing lines and older, partially automated or even manual processing lines being used simultaneously in the same facility.[xlix] A report from 2014 found that the sector does use automation solutions and robotics to differing extents, depending on sub-sector and at the individual organization level.[l] The same report found that within Canadian food manufacturers, the Meat, Fish and Seafood sub-sector has lower levels of automation and robotics than other food and beverage sectors.[li] Additionally, businesses noted that automation priorities were shaped by where they felt they would receive the highest benefits. Many felt raw food/processing and packaging were a priority to automate, while end-of-line applications were less of an automation priority, given the cost-savings received for technology deployment in each stage of the production process.[lii] Most food and beverage processors in Ontario said that within the next three years, technological investments around robotics and automation would be made in equipment for the areas of packaging and food processing.[liii]

Moving forward, Food and Beverage Ontario found that most processors wanted to adopt automation and robotics technology to improve production efficiency and capacity and to reduce labour costs. 91% of responses for a survey circulated by Food and Beverage Ontario indicated that automation and robotics technology were a future priority for the manufacturer.[liv] While a focus on automation always raises questions of labour demand moving forward, the impacts are not anticipated to be high for now.

Although industrial robots have become more common in manufacturing, with an increase in industrial robot density of 48% from 2014 to 2018 in Canada, the number of manufacturing jobs actually increased by 1.2% at the same time; therefore, this report concludes that robot density did not appear to meaningfully influence manufacturing employment over this period.[lv] Over the economy as a whole, it is projected that automation could cause approximately 4% of current jobs to become obsolete over the course of eight years.[lvi] However, it is important to note that these numbers do not consider any job growth as a result of new technologies or occupations,[lvii] like those needed to maintain and repair technologies, which will likely see the creation of new roles and create additional labour demand above what these forecasts can capture.

[Text box: What should be kept in mind when considering adopting new technologies?
There are a number of major points and trends within the innovation and technology adoption literature that are relevant for agriculture and agri-food businesses thinking about their technology adoption journeys. A few notable themes are that:

- Technology adoption needs to be treated as a process that happens and evolves over time, not a static or one-time event. Firms will likely adopt new technologies, then continue to do so as their business needs and the sector continue to evolve. If technology adoption is considered as a process, it allows companies to think about how each additional new technology enhances their competitiveness and productivity, and they will adopt a longer-term perspective beyond the successful use of a single tool or solution.
- Different barriers can hold back the uptake of different technologies. These range from competitive advantages that come with farm size and revenue, to businesses' and employees' technological and/or digital literacy (lack of skills), to businesses' internal conditions and disposition to technology use (see section below on digital intensity and culture).
- Willingness to adopt new technologies is also heavily shaped by the attitudes and preferences of employees, beyond just competitive advantage. These individual attitudes are in turn influenced by how useful employees think the technology will be for their work, how easy they perceive it will be to use, and social norms (peer pressure and conformity).[lviii] One such example is farmers not using precision agriculture tools like yield maps and GPS soil sampling due to a lack of confidence in the resulting data and agronomic recommendations.[lix]
- There is more to technology adoption than digitization. While digitization is an example of technology, it is not all there is to technology adoption. This is especially true for agriculture and related sub-sectors, some of which have complex manual tasks which are difficult to digitize (such as greenhouse and nursery planting, or vegetable and melon planters).[lx] Technologies that may offer efficiency gains for some of these tasks include not just software, but also improvements on existing farm hardware, or even going from physical labour to machinery.
- Hiring and retaining skilled individuals is essential to properly operate and maintain technologies[lxi] - it is not enough to simply purchase and set up the equipment. Having a ready labour pool with the necessary digital skills is a critical foundation for technology adoption and a lack of skilled workers is frequently the greatest barrier that SMEs face in adopting new technologies.[lxii]

- Technology adoption efforts are most successful when employees have technology skills, they receive support and training opportunities to adapt to change, and their perceptions and attitudes towards technology are positive.[lxiii]

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Technology and automation adoption readiness framework

To help companies in agriculture and agri-food sectors evaluate their own readiness to adopt new technologies, this report outlines a framework entitled the "Technology and automation adoption readiness framework." This framework has been created to allow for individual companies to evaluate where they are in their technology adoption journeys and develop a strategic plan for the types of technologies they should consider adopting next.

This framework considers both the organization and its employees in determining technology adoption readiness, and is based off a literature review of a range of credible sources including the Business Development Bank of Canada (BDC). BDC's steps for digitizing a business include having a strategic action plan that defines and shares the company's digital vision, making investments in technology, establishing and fostering a culture of change, collecting and using data for decision-making, and continuous improvements to adapt the business model.[lxiv] BDC also found that organizations making a digital shift should be strategic by assessing their current digital maturity, describing an ideal future state a few years out, and creating a technology implementation plan, especially around IT infrastructure and employing technological skills.[lxv] For any technology adoption effort to be successful, a dedicated budget will be required to invest in new technologies, training, and so forth. Additionally, successful digital transformations involve best practices around operational efficiencies and a culture of change and continuous improvement,[lxvi] such as around planned technology upgrades.

Whether the company uses basic or advanced types of technologies will also influence where a company places themselves within this framework.[lxvii] In agriculture and agri-food, as noted, basic technologies include having an online presence, using social media, e-commerce, and electronic invoicing.[lxviii] Advanced technologies include artificial intelligence and big data, sensors, Internet of Things technologies, GIS, biotechnology, and automated, connected, and electric vehicles, robots, and drones.[lxix]

How to use this framework

Organizations should read through each row and identify which of the four options best describes their current operations. The four columns available each have a number at the top, which indicates the number of "points" a company receives for each response (i.e., a response in column 1 is 1 point, column 2 is 2 points, etc.). An organization should select the option that best describes where they are currently at, recognizing that selecting option 3 means they will already have completed options 1 and 2. Once the organization has gone through all the rows in this framework, they should compile the number of points they scored, and identify where within the four categories below they fall:

- 1-13 points: Limited development - work must be done to plan and build a foundation before adopting new technologies to the workplace.
- 14-26 points: Beginner - early-stage in the technology adoption journey, some basic technologies are used but there is still much to improve upon.
- 27-39 points: Intermediate - a solid foundation is in place and some advanced technologies have been implemented.
- 40-48 points: Expert - many advanced technologies have been successfully implemented.
- 49-52 points: Cutting-edge - ready to assess and adopt emerging technologies as needed.

The objective of this framework is to offer a snapshot of where organizations are in their technology adoption journeys at the point when they take this assessment. If an organization is mostly in column 3, then the rows where they may have scored themselves a 1 or 2 are where they should target their improvement efforts. As noted, technology adoption should be understood as a process, and improving your score can be done through investment, focus, generating employee buy-in, and leadership.

Table 1: Technology and automation adoption readiness framework

	1	2	3	4
Strategic Plan	Technology adoption is not included in the organization's strategic plan	Technology adoption is mentioned	There is an explicit technology adoption component to the strategic plan	There is a comprehensive and adaptable strategy for technology adoption. There is a clear digital vision
Planned technology upgrades	No upgrades planned	Some new technologies are being implemented	New and improved technologies are replacing old ones	New technologies are evaluated and adopted as needed
Budget/ investments	There is no budget dedicated to technology adoption	Some funds are set aside for technology adoption	Technology adoption is budgeted relatively well	Budget items are detailed according to the strategic plan
Types of technology in use - internal; examples	Technology is used for communications, file sharing, and editing	Business management and productivity tools	Analytical, data storage and data management tools. Cloud services, customer relationship management software. Business intelligence technologies	Digital production tools. Big data analytics, enterprise resource planning, Artificial Intelligence. 3D printing. Systems are integrated (especially using Internet of Things systems). Smart sensors. Biotechnology. Geomatics or geospatial technologies
Types of technology in use - external; examples	Informational website, some social media presence, emails	E-commerce/ transactional website, electronic invoicing, digital marketing strategy	Website with customer accounts, personalized content and offers for customers. Supply chain and logistics technologies	Customer service tools have been optimized, new ones are evaluated and integrated as needed
Data collection and use	No data collection occurs	Data is collected and sometimes used in decision-making	Data is collected and used in decision-making	Data is collected and analyzed in real-time, used extensively in decision-making
Current cybersecurity measures	No cybersecurity measures are in place. Simple passwords with no time limits may be used for devices and accounts	Training and awareness (minimum annually), secure passwords that are regularly changed, up to date anti-virus and anti-malware software, regular updates of all IT systems	Limited access to secure servers, policy for content sharing, end-to-end encryption of sensitive data, incident response plan, record retention strategy, advanced authentication systems	Best practices are followed, new methods are adopted as needed
Data backup	No data backup procedures are in place	Data is sometimes backed up	Data is regularly backed up physically	Data is frequently backed up physically and to the cloud

Leadership	Technology adoption is not on the radar	Technology adoption is somewhat valued	Technology adoption is a priority	There are technology adoption champions leading initiatives
Culture of change	No work towards fostering a culture of change	A plan to build a culture of change has been developed and is starting to be implemented	Change is encouraged. Culture, strategy, actions, and structure are aligned	Strong culture of change in the organization. Change management strategy is in place. Everyone is on board
People - current technology skills	Communicate and coordinate electronically	Find and read documents on the Internet. Complete digital forms and commercial transactions online	Use new technologies for coordination, collaboration, and training. Use Internet research skills to problem solve	Continually learn new skills. Use appropriate cybersecurity measures. Can use, maintain, and troubleshoot different technologies
People - support and training opportunities	None offered	Changes are communicated, training resources are shared	Changes are communicated, training tools are offered	Impact assessment of changes is conducted. Proposed changes are a conversation with staff. Training modules are developed and offered
People - technology perceptions and attitudes	New technology is seen as not useful, difficult to learn, and not welcome	New technology is seen as somewhat useful, might take some time to learn, and is welcomed to an extent	New technology is seen as useful, might take a bit of time to learn, and is welcomed	New technology is seen as very useful, easy to learn, and is embraced

The following discusses each row within the framework, and offers insights into how a score can be interpreted and improved upon.

Strategic plan

This metric captures whether an organization has embedded technology adoption into their organizational strategy. Having a comprehensive and adaptable strategy for technology adoption that is part of the overall business plan, as well as a clear digital vision, can show that technology adoption is an organizational priority. It can also offer insights into how this priority will be advanced. Companies with a low score should understand their scores as having not sufficiently prioritized technology adoption to this point, or as having only adopted technologies on an ad hoc basis. Developing a technology adoption strategy will require a thorough evaluation of the organization's internal needs and potentially reaching out to external consultants. Incorporating this strategy with the overall business plan is a key step to normalizing technology adoption, and ensuring alignment across business lines.

Planned technology upgrades

This metric captures whether the organization has planned technology upgrades in place. As noted earlier, adopting new technologies is often done in stages, especially in manufacturing, wherein one facility can have different processing lines with varying degrees of age and automation.[lxx] Having a plan ensures that upgrades and budgets are strategically prioritized and communicated. A low score indicates that the organization may not have assessed their current technology use, or considered where technological improvements would be most advantageous. This score can be improved by identifying operational areas that would benefit from new technologies and incorporating these upgrades into the overall strategic plan and budget.

Budget/ investments

This metric captures whether the organization's budget has funds set aside for technology adoption and is aligned with the strategic plan. A budget will be required to acquire, install, use, and maintain most technology (hardware and software) options. It is also important to consider the potential need for contracted expertise, which may be separate from internal labour costs. A low score means technology adoption is not a priority for the organization, because proper budgetary allocation reflects a stronger level of commitment than strategy alone. This score can be improved by assessing the strategic plan, estimating the cost for adopting technologies identified in the strategic plan and planned technology upgrades, and promising these dedicated funds in the budget.

Types of technology in use – internal

This metric captures the types of technology the organization's employees use. A low score indicates only basic technologies, such as email, video conferencing, and messaging apps for communications and using file sharing and editing tools, are in use, perhaps due to limited organizational capacity. This score could be improved by assessing current internal technology use and which advanced technologies make sense to adopt.

Types of technology in use – external

This metric captures the types of technology the organization uses externally. Basic externally-facing technologies include having an online presence, using social media, e-commerce, and electronic invoicing.[lxxi] Advanced externally-facing technologies tend to have more customer interaction, such as having a company website with individual customer accounts, sending personalized content and offers, and optimizing customer service tools. A low score indicates that only basic technologies are in use, perhaps due to limited organizational capacity. This score could be improved by assessing current client-facing technologies in use and which advanced technologies make sense to adopt.

Data collection and use

This metric captures whether the organization regularly collects data and uses it to make decisions. Data analytics could be visualized through software and used to increase operational efficiencies and productivity and to understand customers. For example, there are mobile applications farmers can use that show real-time data for features like barn conditions, feed levels, crop health and soil conditions, and which allow the farmer to make changes remotely from their smartphone.[lxxii] A low score could indicate that the organization does not possess the skills and/ or other resources required to collect and interpret data to make decisions, or has not yet seen the value in setting up a data collection process. Improving this score would require evaluating which data would be most beneficial to collect and setting up those systems.

Current cybersecurity measures

This metric captures whether the organization has cybersecurity measures in place to prevent cyberattacks like malware (malicious software), viruses, ransomware, spyware, and phishing.[lxxiii] Cybersecurity is a critical yet often overlooked advanced step for businesses adopting technologies.[lxxiv] Best practices include training employees, securing networks, using up to date antivirus software, enabling Multi-Factor Authentication, monitoring and managing any cloud services in use, and securing, protecting, and backing up sensitive data.[lxxv] Companies with a low score may have thought that cybersecurity measures are unnecessary, similar to the 60% of small businesses from the Insurance Bureau of Canada's *2023 Cyber Security Survey*, or may not have deemed it a financial priority, similar to the 69% of respondents from the same survey.[lxxvi] Assessing the organization and closing any cybersecurity gaps, following cybersecurity best practices, creating a plan that is communicated throughout the organization, and ensuring everyone is trained on these best practices would improve this score.

Data backup

This metric captures whether the organization keeps copies of their data so that an emergency like a fire, flood, system failure, theft, or cyberattack does not lead to a complete erasure of their data files. Best practices include frequently backing up critical data in multiple locations, physically onsite or offsite and remotely on the cloud, in formats that can be restored in case the current version is lost.[lxxvii] Ideally, an organization would have policies and procedures around their data backup processes as this will improve their cybersecurity and resiliency.[lxxviii] As this metric falls under the umbrella of cybersecurity, companies with low scores may have also overlooked the importance of implementing data backup procedures, or perhaps simply did not see a need for them up to this point. Improving this score would require evaluating the organization's critical data, determining where to store backup copies and how frequently, and establishing policies and procedures outlining the organization's data backup processes.

Leadership

This metric captures whether the organization's leadership team values technology adoption and spearheads initiatives to support it. This team sets the direction for the organization and its employees. A low score indicates a company where the leadership team has not yet prioritized technology adoption, which can be primarily a forward-thinking exercise. This score could be improved by ensuring the leadership team stays up to date on emerging technologies and thinks about future technology adoptions.

Culture of change

This metric captures whether the organization has a culture of change. Organizations that experience successful digital transformations often have a culture of continuous improvement.[lxxix] A low score may indicate a company that does not have a culture that prioritizes these elements, or that managing change is not an organizational priority. Improving this score includes developing and implementing a change management strategy.

People – current technology skills

This metric captures the technology tasks that most employees in the organization can accomplish using the workplace digital skills identified by the Social Research and Demonstration Corporation (SRDC). The SRDC's six essential digital skills, in order of increasing complexity are: using basic electronic communications for coordination; finding and reading documents on the internet; completing digital forms and commercial transactions online; using new technologies for coordination, collaboration, and training; using internet research skills to problem solve; and using appropriate cybersecurity measures.[lxxx] Having people with the necessary digital skills is a critical foundation for technology adoption.[lxxxi] A low score indicates a company where most employees only use technology in a limited way, such as only communicating through phone and email services. Scores could be improved by including a basic digital skills requirement when hiring and offering training opportunities to existing employees.

People – support and training opportunities

This metric captures whether there is a process in place to facilitate change and whether relevant training is offered to staff to further support technology adoption. Support can help with introducing new technologies and processes into the organization. Offering training can build skills and improve perceptions and attitudes around technology. Companies with a low score may not offer support to ease transitions related to technology adoption or provide training opportunities at the levels employees may need to feel more comfortable. Identifying and prioritizing which skills to offer training on would be the best way to improve an organization's score for this measure.

People – technology perceptions and attitudes

This metric captures how staff in the organization feel about new technologies. The way technology is perceived, especially around usefulness for the job and ease of use, will influence how successful the adoption of new technologies will be.[lxxxii] A low score indicates that employees may be uncomfortable using technology and would not want to have to deal with new technologies. Actions to improve this score could include involving employees in the technology adoption planning stages, sharing information about future changes ahead of time, fostering a culture of change, and providing support and training opportunities.

What barriers exist to adopting new technologies?

Even companies who score as experts, or being on the cutting-edge, still encounter barriers in adopting new technologies. Many of these are structural barriers that affect entire regions, and thus cannot be addressed at the individual business level. The most prominent of these is the urban-rural digital divide, which is important in this context because most technologies, especially advanced ones, require reliable high-speed internet access to be operational and for businesses to achieve digital maturity.[lxxxiii] The following section details the barriers companies may face in their technology adoption journeys in both the agriculture and agri-food sectors.

Lack of reliable internet access

As of 2023, only 59.5% of households in rural and remote areas had the minimum internet connection speed according to the federal government's definition[4].[lxxxiv] This gap between rural/remote households and the Canadian average prevents citizens and businesses from being able to engage with the digital economy and learn, work, and use medical and government services online.[lxxxv] Farmers in rural areas are at a particular disadvantage when it comes to internet access, because even when there is access to a broadband internet connection, it is typically unreliable and expensive,[lxxxvi] thus severely limiting the ability of farms to use internet or cloud-dependent technologies like precision agriculture tools and the Internet of Things.[lxxxvii] Lastly, while new technologies are often presented at in-person trade shows and tours, the onset of the Covid-19 pandemic caused these trade shows to be moved online, thereby making this important platform less accessible to producers in rural areas.[lxxxviii] Given a fiber-optic internet connection is the gold standard for full digital connection because of its higher bandwidth, having access to strong fiber infrastructure will likely be required to support the digital transformation of individual businesses.[lxxxix]

To the extent that these rural areas do have a reliable internet connection, they may not have a workforce with the essential digital skills.[xc] The Social Research and Demonstration Corporation's rural small business employer survey in 2016 found that between 75% to 88% of businesses had staff that did not possess each digital essential skill.[xci] Digital skills are also particularly difficult to find in rural areas,

[4] 50 megabits per second download speed and 10 megabits per second upload speed.

which prevents rural businesses, especially SMEs, from being able to adopt and use the full potential of digital technologies.[xcii]

High capital, operating, and maintenance costs

Costs are among the biggest challenges to technology adoption in agriculture.[xciii] A 2021 survey of farmers (primary producers) and agri-tech businesses found that costs – in particular, equipment, installation, maintenance, and operational costs – were the greatest barriers to technology adoption across the five agricultural sub-sectors that were studied.[xciv] Upfront initial costs to adopt new technologies and equipment are typically high, and SMEs may be unable to make the investment every time a potentially useful new technology emerges.[xcv] This may not be a barrier for larger farms that have high profits, which are often better positioned to afford and adopt new technologies.[xcvi] Additionally, used equipment typically becomes less available as it becomes more specialized. While some older used equipment can be purchased at a lower cost, emerging or specialized technologies are not usually resold until much later, if at all.[xcvii] These cost barriers further widen the technology adoption gap between farms of different sizes. Large farms benefit enormously from precision agriculture technology (which are better suited for farms larger than 500 acres or with an annual income above $75,000),[xcviii] meaning grain and oilseed producers are more likely to adopt precision agriculture tools like variable-rate, GPS, and GIS technologies.[xcix] Finally, the cost of technologies like agricultural robots must be compared to what it is replacing, which in this case is often human labor. Relative to buying, implementing, and maintaining these technologies, human labor may cost less. As such, some farmers may not find the returns on technological agriculture investment to be worth the investment.[c]

In food and beverage manufacturing, a 2022 BDC automation survey identified that more than three-quarters (77%) of food and beverage manufacturers were not investing in automation because of the cost and over two-thirds (68%) reported lacking the resources (time, experience, skills, etc.) to do so.[ci] A 2021 survey of Ontario food and beverage processors found that respondents had a number of financial and operational barriers to automation.[cii] The barriers respondents most identified as substantial were:

- The costs of contracting external automation and robotics maintenance services (67%),
- Costs of implementation delays (64%),
- A lack of skilled labour to operate automation and robotics equipment (64%),
- Lack of available external automation and robotics installation and maintenance services (58%),
- Lack of access to capital (funding) (58%), and
- The cost of hiring and training internal workers to maintain automation and robotics (58%)".[ciii]

This shows that cost barriers go beyond upfront investment, and often relate to the operation, maintenance, and repair of equipment.

Skilled labour shortages

A 2017 BDC survey of manufacturing SMEs noted that the most frequent barrier impeding technology adoption for small manufacturing firms was a shortage of skilled labour, with 42% of firms stressing shortages preventing their ability to adopt new technologies.[civ] In Canada, skilled labour shortages are

often concentrated in roles around researching, designing, building, installing, maintaining, and fixing technologies.[cv, cvi] Additionally, although certain technologies and automation aim to reduce the need for physical labour in response to labour shortages, the new skills required to operate and maintain these technologies can also disincentivize adoption if the local talent pool does not possess the required skills.[cvii]

One particular way skilled labour shortages impede technology uptake is through the operation and maintenance of robotics. Most robotics and automation solutions are manufactured abroad, so technicians and maintenance staff in Canada are not always familiar with how to operate and maintain these technologies. Even in cases where these technologies are manufactured domestically, the wide variety of specific automation scenarios means that multiple skilled workers may be required to support installation and maintenance, depending on the situation, and that the number of individuals to choose from may be limited. Reliance on skilled workers from other regions can create time delays in addressing challenges through time zone differences, inadequate internet for video call consultations, or because a given specialist may need to be flown into a facility if no one is available locally to resolve the challenge. During this time production lines may need to be closed, causing many businesses to see new technologies as risky. Other skilled labour challenges may include having difficulty finding contractors to install equipment.

Uncertainty and buy-in from employers and employees

Across all sub-sectors in agriculture and food and beverage manufacturing, there is uncertainty around returns on investment, the utility of new technologies, and whether rates of innovation make purchasing a given technology a poor choice. Uncertain returns on investment can be a barrier, as producers often want to know that investing in a technology will be beneficial before adopting it.[cviii, cix] The return on investment for adopting specific technologies is typically difficult to quantify because data is shared at the aggregate level and the degree of benefit experienced will vary farm by farm depending on size, wage rate, and type of operation, so each farm would need to make their own calculations.[cx] In food and beverage manufacturing, most processors want to see a return on investment within 2 to 3 years, although some larger enterprises can wait 5 years.[cxi] Canadian food and beverage manufacturers also typically prioritize growth in terms of acquisition and consolidation rather than investing in automation and robotics. Instead of a one-size-fits-all automation solution, more flexible and customized ones are needed because of the varied and short production runs often found in Canadian agriculture and agri-food sectors.[cxii]

The issue of return of investment is also connected to another barrier to technology adoption in agriculture, namely farmers' concerns about the usefulness of technology for their work, with the perception being that these technologies sometimes address nonexistent problems or create more problems than they solve.[cxiii] One example can be seen in precision agriculture adoption, whereby some farmers report low confidence in the recommendations generated by these technologies because the data take too long to analyze and act on. Precision agriculture technologies may also not always be the most useful for their local topography (based on factors such as soil type, levels of rolling ground,

etc.).[cxiv] In the Information and Communications Technology Council's (ICTC) 2021 survey, horticulturists reported the most technology related frustrations, whereas grain and seed respondents reported that their implementation of new technologies seemed to lead to many benefits in the form of increased efficiencies, lower greenhouse gas emissions, larger crop yields, and increased cost savings.[cxv] When agricultural technologies improve performance and have a clear return on investment, users tend to be more positive and satisfied, which may help strengthen and popularize technology adoption.

[*Text box: Agriculture data sharing & challenges*
Data challenges around agriculture solutions are mainly focused on concerns around ownership and data sharing, as well as (dis)trust of the data and the recommendations from it. While many technology companies and manufacturers collect agricultural data, there is little data sharing amongst them. As a result, there is also little agreement between these companies about what farmers should be doing to achieve the best agricultural outcomes, which only serves to confuse farmers and reduce their willingness to adopt new technologies.[cxvi] To the extent that there is data sharing, it may be from the farmers to the technology owners/ providers, which raises concerns amongst farmers who do not always want to "share their data without receiving something in return."[cxvii, cxviii] Lastly, there are also equity and ownership concerns around agriculture data.[cxix, cxx] The farm(er)s who are best positioned to continuously use and benefit from this agricultural data are the larger ones with more capital. Additionally, the data generated by farms is often owned by the technology manufacturers. As such, it is worth being mindful of how increased technology adoption in the agriculture sector may entrench or widen disparities amongst farms, and between farms/ producers and technology manufacturers/ suppliers.
End text box]

Interoperability and Right to Repair

In agriculture, farmers may choose not to purchase new technologies due to concerns about interoperability between assets or their legal ability to repair new machinery. Interoperability is "the ability to interchangeably share, or exchange data between various devices or systems without interference in a way that produces efficiencies or greater knowledge in a particular area."[cxxi] Interoperability challenges with agricultural technologies include: proprietary software constraints and nonexistent or difficult to use APIs (application programming interfaces), which mean technologies from different companies are unable to integrate and work together, and data security issues and insufficient legislation around the right to repair purchased equipment. Under existing technology protection laws, owners are typically not allowed to repair the devices that they have purchased because this ability has been limited to manufacturers and authorized dealers with special diagnostic tools.[cxxii] This presents a problem for farmers, as it can take weeks and hundreds of thousands of dollars for a technician to make an on-farm visit and fix the issue.[cxxiii, cxxiv] These challenges limit a producers' ability to repair expensive equipment that they paid for, can create delays, and may lead some to avoid purchasing advanced technological solutions.[cxxv]

Conclusion

Commented [PM1]: Could we provide some key next step recommendation for how the Automation Working Group could move forward. What is needed to advance this work? How should the framework be implemented?

Technology adoption for Canadian SMEs in agriculture and agri-food is uneven, including at the sub-sector level, but many are well positioned to take advantage of the economic benefits offered from adopting more technologies. This report argues that digital maturity is a spectrum, with some SMEs building a foundation for further technology adoption, others only adopting basic technologies, and some embracing advanced and emerging technologies. Technology adoption readiness, at its core, is determined by the organization and its employees. Whether the organization has a technology adoption component in their strategic plan, planned technology upgrades, a budget for technology investments, technologies already in use, data collection and use procedures, current cybersecurity measures, data backup procedures, leadership promoting technology adoption, and a culture of change. For people, what technology skills they possess, whether support for transitions and training opportunities exist, and their technology perceptions and attitudes. These will all influence the ability of businesses to adopt technology. Our technology adoption readiness framework incorporates these factors so organizations can use the framework to orient themselves on where they are in their technology adoption journey and strategically plan their next steps based on their results.

However, barriers to technology adoption do exist and many of them overlap for SMEs, agricultural producers, and food and beverage manufacturers. For example, high capital, operating, and maintenance costs; skilled labour shortages; uncertainty from employers and employees; and concerns around interoperability and the right to repair equipment. The significant overarching environmental barrier limiting technology adoption for SMEs in these sectors is having access to an affordable and reliable high-speed internet connection, especially for those in rural and remote areas. In order to overcome these barriers, SPI recommends the following steps be taken:

- Encouraging governments to provide funding opportunities for agriculture and agri-food SMEs on their technology adoption journeys.
- Improving legislation around the interoperability of different technologies and the right to repair equipment.
- Ensuring everyone has access to affordable and reliable high-speed internet service.
- Offering digital skills training and information sessions on technologies, new developments, and this technology adoption readiness framework.

Surrounding the use of this framework, SPI recommends that the framework be used to evaluate a small number of leading businesses. This approach to piloting its deployment can support any changes or refinements SMEs make to its application. Once this initial piloting has occurred, SPI recommends rolling this out to a wider group of SMEs in the agriculture and agri-food space to develop a baseline understanding of technology adoption readiness, and that progress be measured every 18-24 months with these businesses to identify how well they are advancing in their journeys.

The barriers identified in this report will need to be addressed moving forward as organizations aim to increase their technology adoption readiness scores and become cutting-edge experts in innovative

technology adoption, creating the competitive edge Canada needs to thrive in the agriculture and agri-food sectors.

Appendix 1.

Use of advanced or emerging technologies in 2019 for Canadian enterprises in agriculture, forestry, fishing and hunting; food manufacturing; and beverage and tobacco product manufacturing.[cxxvi]

North American Industry Classification System (NAICS)	Enterprise size	Advanced technology use	Emerging technology use
Agriculture, forestry, fishing and hunting	Small enterprises (20 to 99 employees)	37%	15.6%
	Medium-sized enterprises (100 to 249 employees)	48.7%	25.9%
	Large enterprises (250 and more employees)	64.9%	26.2%
	Total, all enterprise sizes	38.5%	16.7%
Food manufacturing	Small enterprises (20 to 99 employees)	43.3%	4.7%
	Medium-sized enterprises (100 to 249 employees)	51.5%	14.2%
	Large enterprises (250 and more employees)	52.6%	20.2%
	Total, all enterprise sizes	45.5%	7.7%
Beverage and tobacco product manufacturing	Small enterprises (20 to 99 employees)	44.6%	16.1%
	Medium-sized enterprises (100 to 249 employees)	48.2%	11.3%
	Large enterprises (250 and more employees)	83.9%	20.5%
	Total, all enterprise sizes	47.0%	15.9%

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