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Research article

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Abstract

Technology adoption is essential for improving the growth, productivity and competitiveness of businesses. Previous research suggests that women-owned businesses may be less likely to adopt technologies because they are usually smaller, face more financial constraints, are less likely to access technology knowledge or training, and have different risk-taking preferences. This paper linked two cycles (2017 and 2019) of the Survey of Innovation and Business Strategy with the Canadian Employer-Employee Dynamics Database to study the use of advanced and emerging technologies by women- and men-owned businesses in Canada. The study found some evidence of differences in the use of certain technologies by women-owned businesses, compared with men-owned businesses. Women-owned businesses (12.3%) were less likely to use emerging technologies, such as artificial intelligence, than men-owned businesses (16.5%). However, there was no significant difference in the use of advanced technologies. A Blinder–Oaxaca decomposition showed that the difference in characteristics between women- and men-owned businesses explained about 31% of the overall difference in using emerging technologies. Certain characteristics such as the share of women employees, the average age of employees, business age and profitability played a role in explaining the overall differences.

Keywords: technology adoption, women-owned businesses, emerging technologies, advanced technologies.

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Introduction

Technology adoption is important for the growth and survival of businesses and for enhancing their productivity, efficiency and competitiveness. For example, digital technology—such as cloud computing, big data, 3D printing, the Internet of Things, robotics or artificial intelligence (AI)—improves businesses' growth, productivity and competitiveness (Fudurich et al., 2021). Technology adoption is particularly relevant in the wake of the COVID-19 pandemic, where rapid digital technology adoption improved the adaptability, resilience and survival of firms (Liu, 2021). However, technology adoption among businesses has been uneven (Liu & McDonald-Guimond, 2021). Some businesses have lagged behind others, and the catch-up process for those firms has been intermittent and exclusive. For instance, some studies using very limited data show a gender gap in adopting information and communications technology (ICT) among entrepreneurs (Orser et al., 2019). This paper aims to better understand the differences in technology adoption between women-owned and men-owned businesses in Canada by looking at a broader set of technologies than ICT and using a more recent and complete dataset than previous studies in the literature. Moreover, the paper investigates whether there are any links between characteristics of businesses and employees and the gap in technology adoption between women-owned and men-owned businesses.

Technology adoption is a challenging decision because it is a risky investment, and challenges may be different among businesses, depending on their characteristics and those of their owners and employees (Thong & Yap, 1995). Women-owned businesses may adopt technologies differently than men-owned businesses because of certain characteristics. For example, using a limited number of interviews, Orser et al. (2019) found that women entrepreneurs in Canada were less likely to adopt ICT because they were less likely to have the financial resources to fund technology adoption and to access technology knowledge or training, and had different risk-taking preferences.

Women-owned businesses in Canada, which are smaller than men-owned businesses (Grekou et al., 2018), may face different challenges that could discourage them from adopting new technologies more than men-owned businesses. Findings from a global survey of small and medium-sized businesses show that smaller businesses face different technology adoption barriers than larger businesses. Specifically, smaller businesses listed, in order of significance, a lack of talent, budget and integration complexity as the main barriers, while larger companies cited a lack of strategy, integration complexity, talent shortage and compliance concerns (Evans, 2023).

Moreover, women-owned businesses may face more credit constraints than men-owned businesses to finance their investments.[1] In particular, studies in Canada and elsewhere show that women-owned businesses are more likely to be discouraged borrowers than men-owned businesses (Forrester & Neville, 2021; Huang & Rivard, 2021). Therefore, women-owned businesses may be less likely to adopt new technologies, especially when significant funds are required.

In addition to business and owner characteristics, employee characteristics can also impact technology adoption. As mentioned above, lack of talent or skilled workers is the first concern facing smaller businesses in technology adoption. Other employee characteristics, such as age, can also play a role in adopting technologies. For example, a study on small and medium-sized German firms in the knowledge-intensive and ICT sectors showed that employee age correlated with business technology

1. A business is faced with a credit constraint if any of the following holds: (a) its application to external financing got rejected; (b) it received only a portion of what it applied for; (c) it refused the lender's financing because the borrowing costs were too high; or (d) it did not apply for external financing out of fear that the application would be rejected, i.e., it was a discouraged borrower (Gómez, 2019).

adoption. Specifically, a younger workforce and a more homogenous age positively correlated with the probability of technology adoption (Meyer, 2011).

However, there is not much Canadian evidence, from a business perspective, on the differences in technology adoption between women- and men-owned businesses. To fill this gap, this paper links a technology survey to a matched employer–employee database to examine the patterns of technology adoption by women- and men-owned businesses in Canada. In particular, the paper investigates whether there are any significant differences in technology adoption between women- and men-owned businesses and what can explain those possible differences. Using a Blinder–Oaxaca type of analysis, this paper decomposes the differences in technology adoption into differences in endowments between women- and men-owned businesses (i.e., business and workforce characteristics) and unexplained differences. This paper also examines whether certain employee characteristics, such as age, gender, education and immigrant status, contribute to differences in technology adoption by women- and men-owned businesses. Understanding these differences can help policy makers develop targeted policies to fill any possible gender gaps in technology adoption by businesses.

Data

This project uses a novel data linkage for the main analysis between the Survey of Innovation and Business Strategy (SIBS) and the Canadian Employer-Employee Dynamics Database (CEEDD). On the one hand, the SIBS contains questions on the use of advanced and emerging technologies by businesses, in addition to questions on innovation and business strategies. On the other hand, the CEEDD provides firm-level information on business ownership and employee characteristics within a firm (such as age, education,[2] and the share of women and immigrant employees). It also includes variables on the characteristics of businesses, such as age, profitability, productivity and liquidity. This new data linkage can enable a better understanding of the different patterns of technology adoption between women- and men-owned businesses and how they are related to the different characteristics of businesses, owners and employees.

The SIBS excludes small businesses with fewer than 20 employees or less than $250,000 in revenue. This may lead to a small number of observations for women-owned businesses, which are usually smaller in size than men-owned businesses. It also excludes certain sectors, such as educational services; health care and social assistance; arts, entertainment and recreation; and accommodation and food services. To mitigate the negative impact of this data restriction, the 2017 SIBS and 2019 SIBS are combined, which contain around 21,000 observations.[3] In this paper, a business is said to be owned by women if 50% or more of ownership shares are held by women (hereafter referred to as women-owned). This definition includes businesses where women own 51% or more shares, as in Grekou et al. (2018), and where women and men have equal ownership of 50% to have a sufficiently large number of observations of women-owned businesses, especially across firm sizes and sectors. For majority men-owned (hereafter referred to as men-owned) businesses, men need to have at least 51% of ownership shares.[4] A business is defined as a partially women-owned business if both women and men own less than 50% of shares (for example, 40% of a business is owned by women, 45% by men and 15% by an organization). Moreover, there are some businesses where ownership cannot be

2. Education is imputed using a linkage between the CEEDD, census, Longitudinal Immigration Database and Postsecondary Student Information System. Please see Liu and Lu (2023) for details.
3. For more information about the SIBS, see Statistics Canada (2021, April 26).
4. The CEEDD includes information only on sex at birth from T1 tax returns. Although sex and gender refer to two different concepts, gender is used throughout this article to make it comparable with existing literature on gender differences in technology adoption.

assigned, including publicly traded companies, for which the ownership share can change daily, and some private companies with missing owner information.

In the SIBS, technologies are categorized into two main groups: advanced and emerging technologies. Advanced technologies are classified into seven subcategories: material handling, supply chain or logistics technologies; design or information control technologies; processing or fabrication technologies; clean technologies; security or advanced authentication systems; business intelligence technologies; and other types of advanced technologies (see Table 2). Emerging technologies, as the name suggests, are more recent technologies. Therefore, their definition and subcategories are still evolving. For example, in the 2017 SIBS, emerging technologies were divided into seven subcategories: nanotechnology, biotechnology, geomatics or geospatial technologies, AI, integrated Internet of Things systems, blockchain technologies and other types of emerging technologies. However, in 2019, two more subcategories were added: virtual, mixed and augmented reality; and additive manufacturing. For confidentiality reasons, some of the subcategories were combined to create six subcategories (see Table 3).

Descriptive analysis

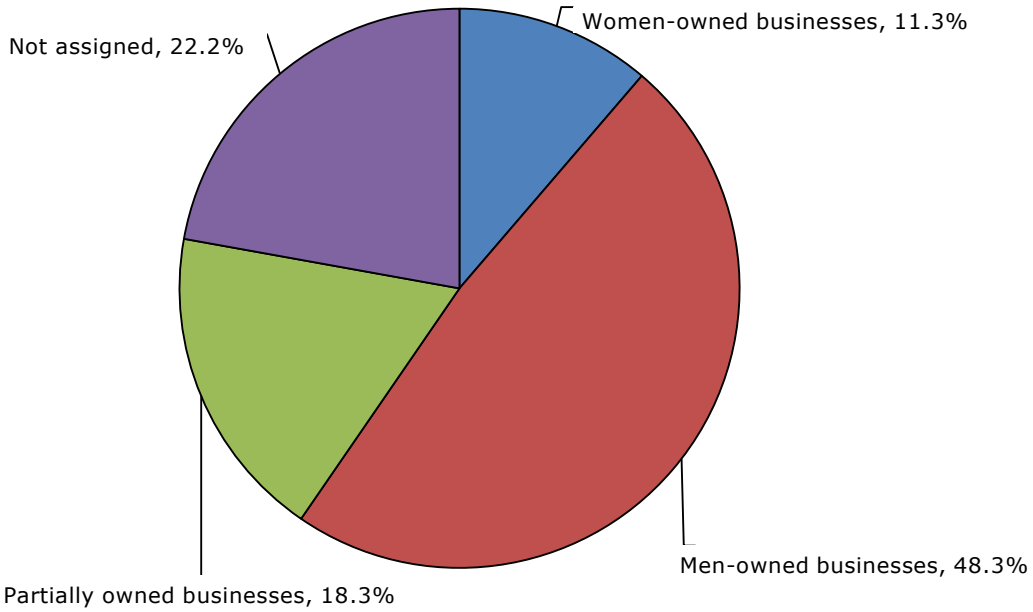
This section presents several descriptive results on the use of technologies by women- and men-owned businesses using the linked SIBS–CEEDD database. To better represent the business population targeted by the SIBS, the sampling weights from the survey were used to produce the following results.

Ownership distribution

Chart 1 shows the weighted distribution of business ownership by gender within the SIBS–CEEDD linked sample. Among businesses with more than 20 employees and $250,000 in revenue, those owned by women represented 11.3% of all businesses, while those owned by men represented 48.1% and those partially owned by women and men represented 18.3%. Businesses to which ownership could not be assigned accounted for 22.2% of all businesses.[5]

5. The authors also sketched the ownership distributions for 2017 and 2019 separately, and the result was almost the same.

Chart 1
Weighted ownership share, 2017 and 2019



Note: Businesses are weighted by their selection probability to obtain the percentage.
Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

Use of technologies

Table 1 illustrates the weighted distribution of users of advanced and emerging technologies[6] by ownership type. Columns 3 and 4 show the use of technologies among women- and men-owned businesses, and the last column displays the p-value, based on which it can be decided whether to reject the null hypothesis that the shares of technology users among women- and men-owned businesses are not significantly different. The results show that, overall, 42.0% of all businesses used at least one form of advanced technologies, 18.1% used emerging technologies and 45.6% used either advanced or emerging technologies. Among women-owned businesses, 33.9% used at least one type of advanced technologies, 12.7% used at least one type of emerging technologies and 37.0% used either advanced or emerging technologies. By comparison, the shares were 38.0%, 16.4% and 42.0%, respectively, among men-owned businesses. However, the difference in the shares of advanced technology users between women- and men-owned businesses was insignificant without controlling for other characteristics. The share of emerging technology users among women-owned businesses was smaller than that among men-owned businesses, and this difference is statistically significant at a 10% level. Similar results are observed for the use of either advanced or emerging technologies. This suggests that women-owned businesses were only less likely to use emerging technologies than men-owned businesses, but not advanced technologies.

6. For simplicity, when a business used or adopted a technology in 2017 or 2019, it is considered to have used the technology in those years. So, a business is referred to as a technology user if it adopted or used at least one kind of advanced or emerging technology in 2017 or 2019.

Table 1
Use of technologies, by technology type and ownership type

Technology type	Overall population	Women-owned businesses	Men-owned businesses	P-value
	percent			
Advanced technologies	42.0	33.9	38.0	0.141
Emerging technologies	18.1	12.7	16.4	0.077
Either advanced or emerging technologies	45.6	37.0	42.0	0.077

Notes: The overall population consists of businesses owned by women or men, partially owned by women or men, or with no assigned ownership. The p-value refers to testing whether the use of technologies by women-owned businesses differed from that of men-owned businesses. Businesses are weighted by their selection probability to obtain the percentage values.
Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

Tables 2 and 3 show the use of specific advanced and emerging technologies by women- and men-owned businesses. Based on the p-values, women-owned businesses were less likely to use advanced technologies than men-owned businesses in two subcategories: design or information control technologies, and processing or fabrication technologies. There were no significant differences by ownership type in the rest of the subcategories.

Table 2
Use of advanced technologies, by subcategory and ownership type

Type of advanced technology	Women-owned businesses	Men-owned businesses	P-value
	percent		
Material handling, supply chain or logistics technologies	9.5	11.8	0.130
Design or information control technologies	10.5	13.5	0.078
Processing or fabrication technologies	7.1	9.2	0.097
Clean technologies	8.4	8.9	0.789
Security or advanced authentication systems	9.1	11.2	0.163
Business intelligence technologies	18.2	19.1	0.699
Other types of advanced technologies	5.9	7.0	0.505

Notes: Some businesses adopted or used more than one type of advanced technology. Accordingly, the sum of each column may be greater than the total percentage of businesses that used or adopted advanced technologies. Businesses are weighted by their selection probability to obtain the percentage values. The p-value shows whether the difference in advanced technology use between women- and men-owned businesses is statistically significant.
Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

Table 3
Use of emerging technologies, by subcategory and ownership type

Type of emerging technology	Women-owned businesses	Men-owned businesses	P-value
	percent		
Nanotechnology or biotechnology	0.6	1.6	0.003
Geomatics or geospatial technologies	1.8	2.8	0.112
Artificial intelligence, or virtual, mixed and augmented reality	1.7	4.4	0.000
Integrated Internet of Things systems	8.4	9.3	0.632
Blockchain technologies or additive manufacturing	0.8	1.6	0.012
Other types of emerging technologies	2.3	2.9	0.455

Notes: Some businesses adopted or used more than one type of emerging technology. Accordingly, the sum of each column may be greater than the total percentage of businesses that used or adopted emerging technologies. Businesses are weighted by their selection probability to obtain the percentage values. The p-value shows whether the difference in emerging technology use between women- and men-owned businesses is statistically significant.
Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

In terms of specific emerging technologies (Table 3), the difference between women- and men-owned businesses in using emerging technologies was more significant than for advanced technologies. In particular, women-owned businesses were less likely to use emerging technologies than men-owned businesses in three subcategories: nanotechnology or biotechnology (0.6% versus 1.6%, respectively); AI, or virtual, mixed and augmented reality (1.7% versus 4.4%, respectively); and blockchain technologies or additive manufacturing (0.8% versus 1.6%, respectively).

Use of technologies by business size

Table 4 demonstrates the use of advanced and emerging technologies by business size and ownership type. Businesses were classified into three size classes: 20 to 99 employees, 100 to 249 employees, and 250 or more employees. First, the results show that the percentage of technology users increased with the size of businesses, regardless of the type of ownership or technology. Second, women-owned businesses were less likely to use advanced technologies than their men-owned counterparts among businesses with at least 100 employees. But the difference was not significant among businesses with fewer than 100 employees. Third, with respect to emerging technologies, there were no significant differences between women- and men-owned businesses, irrespective of business size. When both types of technologies were combined, the significant differences in technology use were found only among businesses with 100 or more employees, similar to the use of advanced technologies. The results may be related to technology investments, which are usually costly. Larger businesses may have more financial resources and incentives to invest in technologies because they can benefit more from the investment given their relatively larger economies of scale.

Table 4
Use of advanced and emerging technologies, by business size and ownership type

	Women-owned businesses	Men-owned businesses	
Technology type and business size	percent		**P-value**
Advanced technologies			
20 to 99 employees	33.4	37.0	0.237
100 to 249 employees	38.8	46.5	0.051
250 or more employees	40.7	52.7	0.004
Emerging technologies			
20 to 99 employees	12.4	15.9	0.120
100 to 249 employees	15.5	20.2	0.105
250 or more employees	19.3	24.0	0.173
Either advanced or emerging technologies			
20 to 99 employees	36.6	41.1	0.154
100 to 249 employees	40.5	50.3	0.014
250 or more employees	43.3	56.2	0.002

Notes: Businesses are weighted by their selection probability to obtain the percentage values. The p-value shows the significance level of the difference in using technology between women- and men-owned businesses.
Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

Use of technologies by sector

Table 5 displays the use of advanced and emerging technologies by sector and ownership type. Businesses are grouped based on the North American Industry Classification System (NAICS). The first group contains the sectors of agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; utilities; and construction (NAICS 11 to 23; hereafter, the primary and construction sector). The second group consists of the manufacturing sector (NAICS 31 to 33). The third group contains wholesale trade, retail trade, and transportation and warehousing (NAICS 41 to 49; hereafter,

the wholesale and retail sector). The fourth group contains information and cultural industries; finance and insurance; real estate and rental and leasing; professional, scientific and technical services; management of companies and enterprises; and administrative and support, waste management and remediation services (NAICS 51 to 56; hereafter, the services sector).

Table 5
Use of advanced and emerging technologies, by sector and ownership type

	Women-owned businesses	Men-owned businesses	
Technology type and sector (two-digit NAICS code)	percent		**P-value**
Advanced technologies			
11 to 23	42.1	35.0	0.467
31 to 33	41.5	48.9	0.077
41 to 49	27.4	33.4	0.152
51 to 56	38.6	42.0	0.496
Emerging technologies			
11 to 23	26.1	16.5	0.351
31 to 33	10.3	16.3	0.011
41 to 49	7.8	12.4	0.059
51 to 56	18.2	23.2	0.194
Either advanced or emerging technologies			
11 to 23	46.5	39.5	0.457
31 to 33	43.8	51.5	0.070
41 to 49	28.4	36.4	0.062
51 to 56	45.8	48.3	0.640

Notes: Businesses are weighted by their selection probability to obtain the percentage values. The p-value shows the significance level of the difference in using technology between women- and men-owned businesses. Industries are grouped based on their North American Industry Classification System (NAICS) code. The first group (11 to 23) contains the sectors of agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; utilities; and construction. The second group (31 to 33) consists of the manufacturing sector. The third group (41 to 49) contains the sectors of wholesale trade, retail trade, and transportation and warehousing. The fourth group (51 to 56) contains information and cultural industries; finance and insurance; real estate and rental and leasing; professional, scientific and technical services; management of companies and enterprises; and administrative and support, waste management and remediation services.

Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

The results show that women-owned businesses (41.5%) were less likely to use advanced technologies than their men-owned counterparts (48.9%) only in the manufacturing sector (NAICS 31 to 33). The difference in the use of advanced technologies in this sector is significant at the 10% level; however, the differences in other sectors are not significant.

Women-owned businesses were less likely to use emerging technologies than men-owned businesses in the manufacturing sector (10.3% vs. 16.3%) and in the wholesale and retail sector (NAICS 41 to 49) (7.8% vs. 12.4%). These differences are significant at the 5% and 10% levels, respectively. The differences are not significant in other sectors. When the two types of technologies are combined, the results are similar to those for emerging technologies.

Across sectors, the share of women-owned businesses using advanced technologies was highest in the primary and construction sector (NAICS 11 to 23) and the manufacturing sector (NAICS 31 to 33), while the share of men-owned businesses using these technologies was highest in the manufacturing sector and the services sector (NAICS 51 to 56). The share of women-owned businesses using emerging technologies was also highest in the primary and construction sector (NAICS 11 to 23), while

the share of men-owned businesses using these technologies was highest in the services sector (NAICS 51 to 56).[7]

Use of technologies by province or region

Table 6 displays the use of technologies by ownership type and province or region. Because of confidentiality concerns, New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island were grouped as "Atlantic Canada," and Alberta, Saskatchewan, Manitoba and the territories were grouped as the "rest of Canada." The results show that women-owned businesses were less likely to use advanced technologies than men-owned businesses (28.4% versus 40.6%, respectively) in the rest of Canada region, while the differences were not significant in other provinces or regions. Women-owned businesses were also less likely to use emerging technologies than men-owned businesses in Quebec (10.8% vs. 16.7%) and the rest of Canada region (6.5% vs. 17.4%). Finally, when both technologies are combined, women-owned businesses were less likely to use either advanced or emerging technologies than men-owned businesses in the rest of Canada region (30.2% vs. 46.7%).

Table 6
Use of advanced and emerging technologies, by province or region and ownership type

Technology type and province or region	Women-owned businesses	Men-owned businesses	P-value
	percent		
Advanced technologies			
Atlantic	29.0	30.7	0.797
Quebec	32.0	34.9	0.546
Ontario	35.3	41.9	0.121
British Columbia	43.1	34.9	0.388
Rest of Canada	28.4	40.6	0.072
Emerging technologies			
Atlantic	9.2	13.4	0.382
Quebec	10.8	16.7	0.029
Ontario	15.0	17.2	0.513
British Columbia	20.1	14.0	0.498
Rest of Canada	6.5	17.4	0.004
Either advanced or emerging technologies			
Atlantic	33.7	33.2	0.944
Quebec	34.9	38.9	0.426
Ontario	40.2	45.3	0.252
British Columbia	43.3	39.1	0.658
Rest of Canada	30.2	46.7	0.016

Notes: Businesses are weighted by their selection probability to obtain the percentage values. The p-value shows the significance level of the difference in using technology between women- and men-owned businesses.

Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

Across provinces and regions, the share of women-owned businesses using advanced or emerging technologies was highest in Ontario and British Columbia, while the share of men-owned businesses using either type of technology was highest in Ontario and the rest of Canada region.

7. It is possible that the patterns by grouped sector may be driven by heterogeneous patterns at more disaggregated industry level, such as at the two- or three-digit NAICS level. However, the data limitations do not allow for a more detailed analysis.

Decomposition analysis

Methodology

The previous section shows some evidence that women-owned businesses used technologies differently than men-owned businesses, and these differences varied by type of technology and business characteristics. This section applies a Blinder–Oaxaca decomposition model while controlling for business and employee characteristics to determine whether these differences still hold. Also, this section investigates what drives differences in technology use between women- and men-owned businesses.

Methodologically, the probability of using either advanced or emerging technologies is estimated for women- and men-owned businesses separately and combined, as follows:

$$Y_w = X_w^{'} \beta_w + \epsilon_w \quad (1)$$

$$Y_m = X_m^{'} \beta_m + \epsilon_m \quad (2)$$

Y_w is a vector of binary variables determining whether a women-owned business used any form of technology. It is equal to 1 when women-owned businesses adopted at least one kind of advanced or emerging technology and 0 otherwise. $X_w^{'}$ contains the characteristics of businesses and employees for women-owned businesses, including employment size, sector and province or region of business, business age, share of skilled employees,[8] shares of women and immigrant employees, and average age of employees. Moreover, the model also controls for the financial conditions of businesses, including the current ratio, the profit margin and labour productivity. The current ratio, which is defined as current liabilities over current assets of a business, measures the liquidity of a business and can be used as a proxy for the credit constraint of the business. The higher the ratio, the lower the liquidity or the higher the credit constraint. The profit margin is defined as the ratio of gross profit over the revenue of a business, and labour productivity is the log ratio of value added over the hours worked by employees.[9] β_w is a vector of coefficients, and ϵ_w is the error term of the women-owned businesses. The regression for men-owned businesses is defined the same way in equation (2).

In the next step, a Blinder–Oaxaca decomposition method is used to examine what causes[10] the gender gap in technology adoption by businesses:

$$\bar{Y}_m - \bar{Y}_w = \left(\bar{X}_m - \bar{X}_w\right)\beta^* + \left[\bar{X}_m\left(\beta_m - \beta^*\right) + \bar{X}_w\left(\beta^* - \beta_w\right)\right] \quad (3)$$

8. The share of employees with a bachelor's degree or higher is used as a proxy for the skilled labour.
9. The employee and financial characteristics of businesses could be affected by the technology adoption of a business. For example, technology adoption can improve labour productivity. Therefore, to mitigate the risk of reversed causality, one-year lags were used as independent variables for those characteristics, i.e., the share of skilled employees, the average age of employees, the share of women employees, the share of immigrant employees and the financial characteristics of businesses. The data showed that the gender of ownership barely changed within a short period. For example, from 2017 to 2019, 2% of women-owned businesses switched to men-owned status. Sensitivity checks for using independent variables with two- and three-year lags, as well as no lags, showed that the overall results were generally robust.
10. See Oaxaca and Ransom (1994) and Jann (2008) for more details on technical derivations.

Therefore, the gender difference in technology adoption—the left-hand side of equation (3)—can be decomposed to the following:

a) The difference in endowments (or observable characteristics) of women- and men-owned businesses (i.e., the first term on the right-hand side of equation (3)).

b) The unexplained difference (i.e., the term included in the square bracket on the right-hand side). Essentially, it measures the difference caused by the various coefficients between one specific type of business and an average business. For example, $\bar{X}_w(\beta^* - \beta_w)$ measures the difference attributable to various coefficients of women-owned businesses compared with an average business, irrespective of ownership type, β^*. β^* is derived from a pooled model where both men- and women-owned businesses were included, as well as an ownership binary variable. Since men-owned businesses normally dominate, the difference between β_m and β^* is small. Therefore, the unexplained difference is mainly driven by different coefficients between women-owned businesses and an average business. The coefficients β can be interpreted as marginal returns of specific variables to technology adoption. For instance, the coefficient on average employee age shows the change in the likelihood of using technologies if average age increases by one year. If this coefficient were very different between a women-owned business and an average business, it would suggest that the incentives or costs of using technologies with respect to employee age are very different between the two types of businesses.

In the literature, the unexplained difference is sometimes referred to as possible discrimination. For example, women-owned businesses might receive unfavourable treatment from financial institutions regarding their credit applications, which may affect their decisions on technology adoption. It is important to note that this unexplained difference also includes those potential effects of differences in unobserved variables, such as managerial skills.

Decomposition results

Table 7 shows the summary statistics of independent variables used in equations (1) to (3). It displays the summary statistics for women- and men-owned businesses linked to the SIBS. For example, column 3 indicates that women-owned businesses employed an average of 44 employees, 17% of employees in women-owned businesses were skilled (with a bachelor's degree or higher), the average age of employees in women-owned businesses was 38.7, 45% of employees in women-owned businesses were women and 18% of employees in women-owned businesses were immigrants. Women-owned businesses were, on average, aged 18.5 years, with a current ratio of 2.1, labour productivity (in log value) of 3.4 and a gross profit margin of 36%.[11] The last column illustrates p-values, which indicate whether the results of mean differences for any given variable are statistically significant. For example, on average, women-owned businesses were smaller in terms of employment and had a relatively higher share of skilled labour, a much higher share of women employees, and lower labour productivity than men-owned businesses.[12]

Table 7
Summary statistics of regressors

	Women-owned businesses		Men-owned businesses		Testing the mean difference
Variables	Number of linked observations	Weighted mean	Number of linked observations	Weighted mean	(P-value)
Employment size	1,479	44.10	6,829	49.21	0.011
Share of skilled employees	1,523	0.17	7,000	0.14	0.019
Average age of employees (years)	1,504	38.66	6,918	39.33	0.075
Share of women employees	1,504	0.45	6,918	0.31	0.000
Share of immigrant employees	1,504	0.18	6,918	0.16	0.061
Business age (years)	1,524	18.53	6,969	20.91	0.000
Current ratio	1,475	2.13	6,832	2.09	0.642
Labour productivity	1,427	3.41	6,653	3.56	0.000
Profit margin	1,431	0.36	6,611	0.32	0.032

Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

Table 8 shows the decomposition results: the difference in the likelihood of using technologies by women- and men-owned businesses while controlling for business characteristics (i.e., sector, business size, province or region, and business age), employee characteristics (i.e., average age, shares of women and immigrant employees, and share of skilled employees) and business financial characteristics (i.e., current ratio, labour productivity and profit margin).

11. The gross profit margin is calculated as the ratio of gross profit over the revenue of a business. The gross profit is defined as total revenue minus the cost of goods sold.
12. Patterns similar to those shown in Table 7 are also observed if examining the universe of men- and women-owned businesses in the CEEDD with the same exclusions as the SIBS, i.e., excluding businesses with fewer than 20 employees or less than $250,000 in revenue.

Table 8
Decomposition results on the difference in using technologies between women- and men-owned businesses

Blinder–Oaxaca decomposition model	Advanced technologies		Emerging technologies		Either advanced or emerging technologies	
	coefficient	p-value	coefficient	p-value	coefficient	p-value
Overall difference						
Men-owned businesses	0.380	0.000	0.165	0.000	0.422	0.000
Women-owned businesses	0.353	0.000	0.123	0.001	0.376	0.000
Difference	0.027	0.352	0.042	0.070	0.046	0.186
Explained difference	0.006	0.458	0.013	0.013	0.005	0.463
Unexplained difference	0.021	0.378	0.029	0.261	0.041	0.163
Explained difference						
Sector (base: NAICS 31 to 33)						
NAICS 11 to 23	-0.018	0.210	0.003	0.283	-0.016	0.213
NAICS 41 to 49	0.013	0.164	0.003	0.204	0.013	0.167
NAICS 51 to 59	0.007	0.437	-0.001	0.515	0.005	0.444
Province or region (base: Ontario)						
Atlantic	0.000	0.509	0.000	0.454	0.000	0.461
Quebec	-0.002	0.265	0.001	0.517	-0.002	0.172
British Columbia	0.002	0.283	0.001	0.771	0.001	0.673
Rest of Canada	0.000	0.905	0.000	0.905	0.000	0.905
Business size (base: 20 to 99 employees)						
100 to 249 employees	0.000	0.924	0.000	0.925	0.000	0.924
250 or more employees	0.000	0.442	0.000	0.409	0.000	0.443
Share of skilled employees	-0.004	0.241	-0.005	0.112	-0.006	0.183
Average age of employees	-0.003	0.056	-0.002	0.004	-0.003	0.022
Share of women employees	0.003	0.652	0.011	0.022	0.009	0.136
Share of immigrant employees	-0.004	0.082	0.000	0.796	-0.003	0.197
Business age	0.002	0.186	0.001	0.587	0.001	0.498
Current ratio	0.001	0.259	0.000	0.388	0.001	0.372
Labour productivity (log)	0.011	0.003	0.004	0.135	0.008	0.006
Gross profit ratio	-0.002	0.183	-0.001	0.099	-0.003	0.079
Unexplained difference						
Sector (base: NAICS 31 to 33)						
NAICS 11 to 23	-0.015	0.389	-0.008	0.240	-0.016	0.400
NAICS 41 to 49	0.009	0.481	-0.002	0.595	0.017	0.265
NAICS 51 to 59	-0.011	0.496	-0.004	0.466	-0.006	0.573
Province or region (base: Ontario)						
Atlantic	0.000	0.956	0.002	0.247	0.001	0.719
Quebec	0.005	0.636	0.000	0.879	0.004	0.743
British Columbia	0.021	0.002	0.010	0.190	0.028	0.000
Rest of Canada	-0.022	0.015	-0.008	0.091	-0.019	0.080
Business size (base: 20 to 99 employees)						
100 to 249 employees	0.003	0.027	0.000	0.983	0.004	0.042
250 or more employees	0.001	0.275	0.000	0.722	0.001	0.269
Share of skilled employees	0.022	0.547	0.002	0.738	0.021	0.565
Average age of employees	-0.203	0.136	-0.069	0.124	-0.174	0.123
Share of women employees	-0.041	0.109	0.030	0.074	-0.030	0.222
Share of immigrant employees	0.044	0.055	-0.002	0.884	0.042	0.034
Business age	-0.035	0.002	-0.029	0.031	-0.047	0.062
Current ratio	0.027	0.053	0.004	0.566	0.036	0.125
Labour productivity (log)	0.042	0.477	-0.033	0.448	-0.032	0.458
Gross profit ratio	-0.026	0.001	-0.023	0.069	-0.022	0.169
Constant term	0.200	0.402	0.160	0.024	0.232	0.210

Notes: Sectors are grouped based on their North American Industry Classification System (NAICS) code. The first group NAICS 11 to 23) contains the sectors of agriculture, forestry, fishing and hunting; mining, quarrying, and oil and gas extraction; utilities; and construction. The second group (NAICS 31 to 33) consists of the manufacturing sector. The third group (NAICS 41 to 49) contains the sectors of wholesale trade, retail trade, and transportation and warehousing. The fourth group (NAICS 51 to 59) contains information and cultural industries; finance and insurance; real estate and rental and leasing; professional, scientific and technical services; management of companies and enterprises; and administrative and support, waste management and remediation services.

Source: Authors' calculations using the Survey of Innovation and Business Strategy and Canadian Employer–Employee Dynamics Database.

The top panel of Table 8 shows the average predicted probabilities of using technologies among women- and men-owned businesses, their overall differences, and the part of the differences related to the characteristics (explained) and the unexplained part. The overall difference between women- and men-owned businesses was significant only for emerging technologies, but not for advanced technologies or the two types combined. Specifically, women-owned businesses (12.3%) were less likely to use emerging technologies than men-owned businesses (16.5%). The decomposition results show that the difference in characteristics between women- and men-owned businesses contributed 1.3 percentage points of this difference in the use of emerging technologies, equivalent to about 31% of the overall difference. In other words, if the characteristics of women-owned businesses were the same as those of men-owned businesses, the likelihood of women-owned businesses using emerging technologies could increase by 1.3 percentage points. The unexplained difference contributed about 69% of the overall difference, although this difference was not statistically significant.

Looking at the contribution of observed characteristics, the middle panel of Table 8 suggests that the average age of employees, the share of women employees and the profit margin play an important role in explaining the difference in the use of emerging technologies between women- and men-owned businesses. Based on the decomposition results, if the average age of employees for women-owned businesses were the same as that for men-owned businesses, the likelihood of technology adoption by women-owned businesses would decrease by 0.2 percentage points for emerging technology. As shown in Table 7, employees working in women-owned businesses were, on average, slightly younger than those in men-owned businesses—38.5 years vs. 39.3 years—contributing positively to technology adoption by women-owned businesses. This could reflect that younger workers are more supportive of technology adoption. Meyer (2011) also finds that businesses with younger employees would be more likely to adopt ICT than businesses with older employees. The share of women employees was also significantly correlated with the use of emerging technologies. The share of women employees was 45% for women-owned businesses and 31% for men-owned businesses in the data.[13] Based on the decomposition results, if women-owned businesses had the same share of women employees as men-owned businesses, their likelihood of using emerging technologies could increase by 1.1 percentage points, accounting for almost 85% of the total explained difference. This does not necessarily mean that women-owned businesses should hire fewer women employees. Instead, it may partially reflect the fact that women are less likely to hold science, technology, engineering and mathematics (STEM) degrees than men in Canada (Chan et al., 2021; Ferguson, 2016; Hango, 2013). More STEM or technology-related training could help employees better prepare for new technologies. In addition, the profit margin of businesses also partially explained differences in emerging technology adoption. On average, women-owned businesses reported a higher profit ratio, as shown in Table 7. If women-owned businesses had the same profit ratio as men-owned businesses, the likelihood of emerging technology adoption would decline by 0.1 percentage points. Businesses with higher profit margins could generate more cash flows that fund future investment in technologies.

While the overall differences in observed characteristics were not statistically significant in explaining the gaps in advanced technology adoption or gaps in the adoption of the two technologies combined between women- and men-owned businesses, certain characteristics still played a role in those gaps. For example, if the average age of employees in women-owned businesses were the same as that for men-owned businesses, the likelihood of women-owned businesses using advanced technologies would decrease by 0.3 percentage points. As mentioned above, this could be because employees hired by men-owned businesses were, on average, older. The decomposition results also show that if women-owned businesses had the same share of immigrant employees as men-owned businesses, their likelihood of using advanced technologies would decrease by 0.4 percentage points. Women-

13. The above calculation is based on the linked CEEDD-SIBS sample, which excluded small businesses fewer than 20 employees. If looking at all sizes of business ownership in the CEEDD, the share of women employees for women-owned businesses (women owning at least 50% of the ownership share) in 2019 was 54%, compared with 37% for men-owned businesses.

owned businesses were more likely to hire immigrant employees than men-owned businesses (Table 7). This result implies a positive correlation between immigrant employees and technology adoption because immigrant employees are more likely to study and work in fields related to technology. For instance, findings from the 2016 Census show that immigrants represented 24% of the national workforce but accounted for 39% of computer programmers, 41% of engineers and more than 50% of chemists (Immigration, Refugees and Citizenship Canada, 2022). The labour productivity of businesses also partially explained the differences in technology adoption. As shown in Table 7, labour productivity was lower among women-owned businesses than men-owned businesses. If women-owned businesses had the same labour productivity as men-owned businesses, their likelihood of using advanced and combined technologies would increase by 1.1 and 0.8 percentage points, respectively. This result suggests a positive correlation between labour productivity and technology adoption. When labour productivity increases, businesses often seek ways to further optimize their operations to meet increasing demand and maintain or enhance their competitive edge. Adopting technology can be a strategic response to this need, as it enables companies to achieve higher levels of productivity or facilitate innovation to bring new products, services or processes that differentiate them from competitors.

While the overall unexplained difference was not statistically significant in explaining the technology adoption gaps, certain specific characteristics were found to be important. For example, if women-owned businesses faced the same marginal return as an average business to adopting emerging technologies, with respect to women employees, this would increase the likelihood of women-owned businesses using emerging technologies by 3.0 percentage points. This result suggests that women-owned businesses faced either lower incentives or higher costs of using emerging technologies, with respect to women employees, than an average business. This could align with findings that women earn less than men, on average. For example, in 2022, women's labour income was 12% less than men's labour income (Drolet & Amini, 2023). Therefore, women-owned businesses that proportionally hired more women than men-owned businesses could have lower labour costs, and thus less incentive to adopt technology, if labour and technology are substitutes. Or it could be that training costs for technology adoption are higher for women-owned businesses that proportionally hired more women who were less likely to hold STEM degrees. A similar result was found for the share of immigrant employees in advanced technology adoption. For example, if women-owned businesses faced the same marginal return as an average business to adopting advanced technologies, with respect to immigrant employees, this would increase the likelihood of women-owned businesses using advanced technologies by 4.4 percentage points. Studies also found that immigrants' labour income was lower than that of Canadian-born individuals, on average (Crossman et al., 2021). Thus, women-owned businesses, which proportionally hired more immigrants, may also have less incentive to adopt technology. The unexplained difference with respect to the current ratio also played a role. If women-owned businesses faced the same marginal return as an average business to adopting advanced technologies, with respect to the current ratio (a measure of liquidity condition), this would increase the likelihood of women-owned businesses using advanced technologies by 2.7 percentage points. This may also suggest that there are some hidden or extra costs or unfavourable financial conditions for women-owned businesses, consistent with the finding that women-owned businesses were more likely to face credit constraints or be discouraged borrowers (Forrester & Neville, 2021; Huang & Rivard, 2021).

Conclusion and discussion

Technology adoption is essential for improving the growth, productivity and competitiveness of businesses. Studies also showed that digital technology adoption improved firms' adaptability, resilience and survival during the COVID-19 pandemic. However, businesses have not adopted technology evenly. For example, Orser et al. (2019) find that women entrepreneurs in Canada were less likely to adopt information and communications technology (ICT) because they were less likely to have the financial resources to fund technology adoption and to access technology knowledge or training, and had different risk-taking preferences.

This paper linked two cycles of the Survey of Innovation and Business Strategy (SIBS) (2017 and 2019) with the Canadian Employer-Employee Dynamics Database (CEEDD) to study differences in the use of advanced and emerging technologies by women- and men-owned businesses in Canada. The analysis used a Blinder–Oaxaca type of decomposition and controlled for characteristics of businesses and employees. Unlike other studies, this study found that the difference in the use of technologies between women- and men-owned businesses existed only for certain types of technologies. While there were no significant differences in the use of advanced technologies between women- and men-owned businesses, women-owned businesses were 4.2 percentage points less likely to use emerging technologies, such as AI, than men-owned businesses.

About 31% of this difference in the use of emerging technologies can be attributed to different characteristics between women- and men-owned businesses. Among these characteristics, the share of women employees in a business played an important role in explaining the difference. Women-owned businesses tend to hire more women proportionally than men-owned businesses. If women-owned businesses had the same share of women employees as men-owned businesses, their likelihood of using emerging technologies could increase by 1.1 percentage points. This does not necessarily mean that women-owned businesses should hire fewer women employees. Instead, it may partially relate to the fact that women are less likely to hold science, technology, engineering and mathematics (STEM) degrees than men in Canada (Chan et al., 2021; Ferguson, 2016; Hango, 2013). More STEM or technology-related training could help employees better prepare for new technologies. This study also found that a younger workforce, a higher share of immigrant employees and higher labour productivity could help women-owned businesses improve their use of technologies.

The unexplained difference with respect to the current ratio also played an important role. Women-owned businesses could increase their likelihood of using advanced technologies if their incentives or costs of using advanced technologies, with respect to their liquidity conditions, were similar to those of an average business. On one hand, this may suggest that women-owned businesses might face unfavourable credit situations that prevent them from adopting technologies. On the other hand, technology adoption may reduce information asymmetry between businesses and financial institutions and act as a signal of innovativeness, thus helping businesses obtain better credit conditions (Pellegrina et al., 2017).

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