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Adoption of Digital Technologies: Insights from a Global Survey Initiative

by James Fudurich,[1] Lena Suchanek[2] and Lise Pichette[1]

[1]Canadian Economic Analysis Department
Bank of Canada, Ottawa, Ontario, Canada K1A 0G9

[2]International Economic Analysis Department
Bank of Canada, Ottawa, Ontario, Canada K1A 0G9

jfudurich@bankofcanada.ca, lsuchanek@bankofcanada.ca

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Abstract

The Bank of Canada, together with a global network of central banks, recently surveyed more than 6,000 firms from around the world. Using the survey data, this paper assesses the effects of digitalization on firms' pricing and employment decisions. Specifically, we examine firms' expectations about how their adoption of digital technologies—such as e-commerce, cloud computing, big data, 3-D printing, the Internet of Things, robotics and artificial intelligence—will affect their prices and hiring plans. Digital technologies influence firms' operations in several ways that can often offset each other. This makes it difficult to pin down the overall impact on prices. Survey results for Canada suggest that some firms expect some downward pressure on prices from (1) efficiency gains, for example from automation, made possible by digital technology and (2) increased online competition and cost compression in the supply chain. Other firms expect that the value added to their products from adopting digital technologies will allow them to charge higher prices. In addition, some firms anticipate that they will have to pass on the costs of adoption to customers. Firms also expect a marginal negative effect on their employment over the next three years as a result of technology-induced automation or productivity gains. This negative effect will largely be offset by more hiring of digital talent or to accommodate stronger sales. Using matching techniques to control for differences in sample size and composition as well as survey frames, we find that, compared with small and medium-sized firms, large firms are more likely to adopt digital technologies and more likely to expect negative effects on both employment and prices.

Topics: Firm dynamics; Inflation and prices; Labour markets
JEL codes: D22, E31, J21, O33

Résumé

La Banque du Canada, en collaboration avec un réseau international de banques centrales, a récemment interrogé plus de 6 000 entreprises de partout dans le monde. Sur la base des données recueillies, nous évaluons les effets de la numérisation sur les décisions relatives aux prix et à l'emploi. Plus précisément, nous examinons les attentes des entreprises quant à l'incidence de la mise en œuvre de technologies numériques telles que le commerce électronique, l'infonuagique, les mégadonnées, l'impression 3D, l'Internet des objets, la robotique et l'intelligence artificielle sur leurs prix et leurs plans d'embauche. Comme les effets variés de ces technologies sur les activités peuvent souvent se compenser, il est difficile d'en déterminer l'impact global sur les prix. Selon les résultats de l'enquête pour le Canada, certaines entreprises s'attendent à ce que les prix subissent des pressions à la baisse entraînées par 1) les gains d'efficience, associés à l'automatisation par exemple, et 2) la concurrence accrue en ligne et la compression des coûts dans la chaîne d'approvisionnement. D'autres estiment que la valeur ajoutée à leurs produits grâce aux technologies numériques leur permettra d'augmenter leurs prix. D'autres encore prévoient qu'elles devront répercuter sur leurs clients les coûts engendrés par l'adoption de telles technologies. Les entreprises anticipent également un effet négatif marginal sur leur niveau d'emploi au cours des trois prochaines années en raison de l'automatisation ou de gains de productivité découlant de la technologie. Cet effet sera largement compensé par l'embauche d'un nombre accru de ressources compétentes dans le numérique ou destinées à soutenir une hausse des ventes. À l'aide de techniques d'appariement, nous arrivons à tenir compte des différences dans la taille et la composition des échantillons ainsi que dans les paramètres d'enquête. Nous constatons ainsi que, par rapport aux petites et moyennes entreprises, les grandes entreprises sont plus susceptibles d'adopter des technologies numériques et d'anticiper des effets négatifs sur leur niveau d'emploi et leurs prix.

Sujets : Dynamique des entreprises; Inflation et prix; Marchés du travail
Codes JEL : D22, E31, J21, O33

Key messages

- Canadian firms surveyed in the 2018 summer *Business Outlook Survey* (BOS) are adopting digital technologies to varying degrees, from high rates of adoption of cloud computing and e-commerce to low rates for 3-D printing and artificial intelligence (AI). Large firms uniformly show higher rates of adoption compared with small firms. An online consultation of only small firms also shows overall lower adoption rates for small firms.
- While the multifaceted and often offsetting channels through which digitialization affects firms' prices make it difficult to pin down an overall impact, results point to expectations of small downward pressure on prices, mostly through indirect channels:
    - Most firms surveyed in the BOS expect offsetting or no *direct* effects on prices as a result of their adoption of digital technologies over the next three years. Some expect upward pressure on their prices largely as a result of high costs for implementation. Others judge that adoption adds (digital) value to their products, allowing them to charge higher prices (an ambiguous effect in quality-adjusted terms). On the other hand, digitally enabled efficiency gains such as automation are the most prominent reason behind expected cost and price reductions. Small firms see overall more positive pressure on prices.
    - In contrast, when asked about any *indirect* effects of digitalization, firms expect a net disinflationary impact on their prices, including through increased online competition and cost compression in the supply chain.
- On balance, BOS firms expect that over the next three years the negative effect on their employment due to technology-induced automation or productivity gains (both labour-replacing and labour-augmenting) will be marginal. This is because it will be largely offset by stronger hiring to implement digitalization or to accommodate stronger sales. Compared with small firms, large firms and firms in the goods sector more often report that they expect negative effects.

- Global survey results from 11 other central banks are qualitatively in line with Canadian results but vary in terms of size of impacts across countries. Using matching techniques to control for differences in sample size, composition and survey frame, we find that large firms are higher adopters and expect overall more downward pressure on prices (mainly through indirect channels) and employment.

Introduction

The network of central bank business surveys and liaison programs includes around 25 central banks that conduct surveys. In spring 2018, the group coordinated a global survey initiative, asking common questions on a topic of broad interest in their respective business surveys.[1] The main objective of this first global survey was to look at how adopting digital technology affects firms.[2]

This paper reports the results from 12 central banks for a total of 6,050 firms surveyed (see **Table A-1** in the Appendix for a list of participants). Firms were asked which digital technologies they are adopting. The main focus of the survey was to understand whether firms' digitalization had any direct impact on their prices. The Bank of Canada and all other participating central banks are inflation-targeting central banks; it is therefore crucial that we understand how the digital transformation of the economy might affect prices.[3] In considering the various channels through which digitalization affects the economy, we also investigated whether digitalization has any *indirect* impact on firms' prices. For instance, the fact that their competitors, customers or suppliers move toward digital processes, goods and habits can affect firms' pricing power and decisions, whether or not the firms themselves adopt those innovations. Finally, amid a growing literature on the power of new technologies to transform the labour market, we asked firms to what extent they expect the adoption of digital technologies to influence their employment decisions within the next three years.

[1] The Canadian survey was conducted as part of the Bank of Canada's quarterly Business Outlook Survey (BOS) and electronic BOS (e-BOS) interviews between May 3 and June 5, 2018. The Bank of Italy conducted its survey in the first quarter of 2018, and the other central banks conducted their surveys in the second quarter of 2018.

[2] Another objective of this global initiative was to experiment with and learn from a collaborative survey effort.

[3] While a growing literature investigates the price effects of e-commerce, and in particular how much online and offline prices differ, here we investigate not ex post actual prices, but the *direction of pressures* on prices, captured through firms' responses.

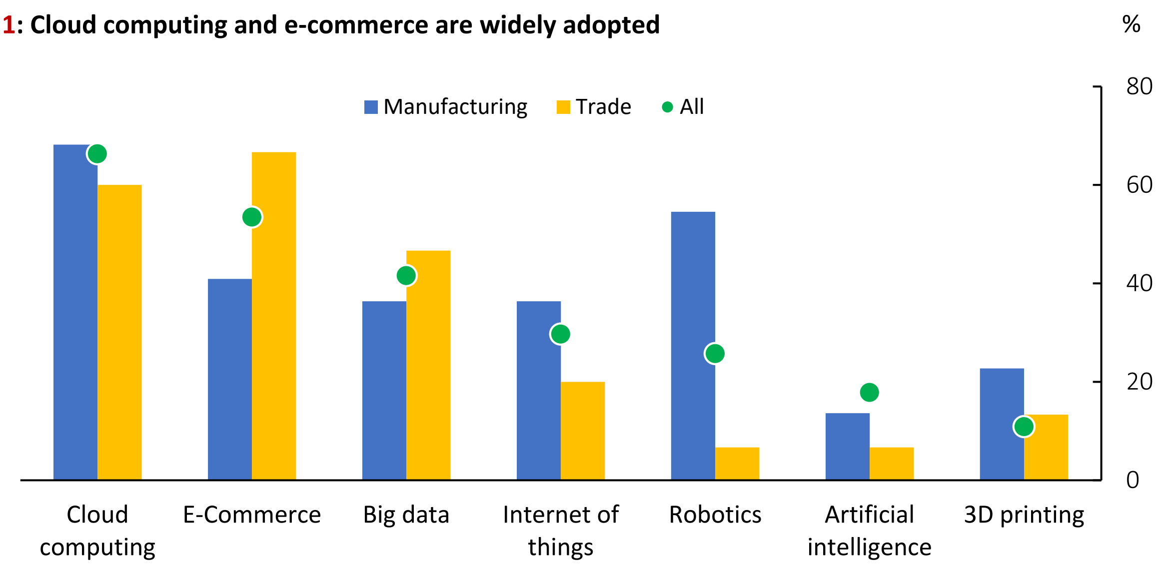
The first section of this paper reports results for Canadian firms from the Business Outlook Survey (BOS), and the second presents global results based on data from our network of central banks.

Section 1 | Canadian results

This section discusses results for Canada, collected as part of the summer 2018 BOS. The BOS sample composition is roughly representative of business sector gross domestic product (GDP) in terms of region, sector and firm size; thus, it is a useful benchmark for understanding the implications of digitalization for the Canadian economy.[4]

1.1 Adoption of technologies

Chart 1: Cloud computing and e-commerce are widely adopted



Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

To understand the extent of their digitalization, we asked firms which digital technologies they have implemeted or started to implement.[5] BOS results suggest that of the digital technologies, cloud computing and e-commerce have been adopted by the most Canadian firms (66 percent and

[4] In particular, the sample of approximately 100 firms each quarter includes a quota for each region that is further divided into two- and three-digit North American Industry Classification System (NAICS) code quotas. Regions in the BOS include British Columbia and Yukon, Prairies (Alberta, Saskatchewan, Manitoba, Northwest Territories and Nunavut), Ontario, Quebec and Atlantic (New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador). Nationally, the sample composition is divided into roughly even groups of small firms (fewer than 100 employees), medium-sized firms (100 to 499 employees) and large firms (500 or more employees). Results from a complementary online consultation conducted in the second quarter of 2018 with a sample of 502 small firms are summarized in Appendix A.2.

[5] For exact wording and the complete questionnaire, see Appendix A.1.

53 percent of firms, respectively), followed by big data (42 percent), the Internet of Things (30 percent) and robotics (26 percent).[6] Consistent with findings in the literature and prior evidence for Canada, large firms almost universally reported higher shares of adoption than did small or medium-sized firms.[7]

Not surprisingly, manufacturing firms cited robotics, the Internet of Things and 3-D printing more often than firms in other sectors. Firms in the trade sector are heavy adopters of e-commerce and big data (**Chart 1**). Some firms reported that digital technologies allow them to increase their market reach, increase the visibility of their product and drive more traffic to their business. Others said adopting these technologies is necessary to remain competitive.

1.2 Direct impact on prices

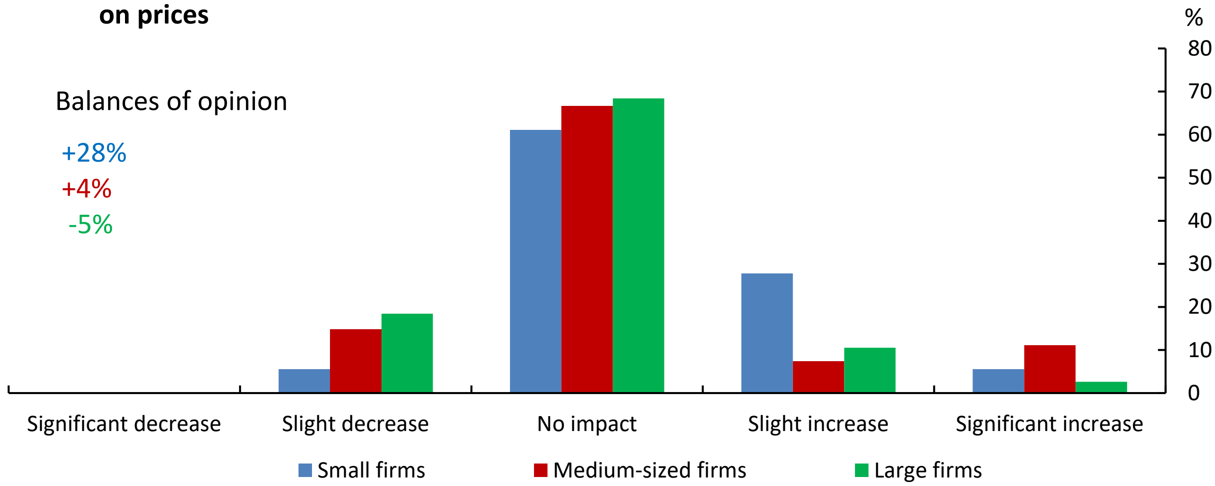
The adoption of digital technologies affects firms' prices in various ways, such as through digitally enabled cost efficiencies. To capture the overall expected impact, we first asked our respondents whether they expect their adoption of technology to affect their prices over the next three years. Most firms reported little or no direct impact on their output prices. On balance, more firms reported upward pressure on prices than reported downward pressure (balance of opinion of +5 percent, **Chart 2**).

Several firms, often those in the services sector, that expect upward price pressure pointed to high costs associated with implementation, such as hiring experts to implement or maintain the technology or acquiring expensive hardware or software (e.g., costs of digital equipment and related maintenance, and third-party services and software). Other firms expect that technology adoption will lead to higher demand for their products, allowing them to increase their prices. A prominent example is trade firms that have adopted e-commerce (e.g., in an effort to reach new clientele). Other firms, often in the goods sector, judge that digital technologies are an integral part of the product they sell, allowing for higher prices (i.e., quality enhancements). These firms may expect to sell a more customizable product. Note that while improvements in quality appear as a net positive impact on prices in our survey, Statistics Canada accounts for quality

[6] Besides the response options identified in **Chart 1**, other, less frequently cited technologies include virtual or augmented reality, enterprise resource planning software, drones, blockchain technology and cyber security.
[7] Larger firms are more likely to be "frontier firms"; see Andrews, Criscuolo and Gal (2015). For Canadian evidence, see Thomas (2016) and Conference Board of Canada (2013).

improvements when constructing the consumer price index (CPI). This suggests that our survey results somewhat overstate the inflationary impact of digital technologies.[8]

Chart 2: Small and medium-sized BOS firms cite more inflationary direct impacts on prices



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

Several firms also see downward pressure on prices as they adopt digital technology. This downward pressure is most often the result of technology-enabled cost efficiencies that are passed on to their customers. For firms in the goods sector, robotics is the primary driver of cost savings. Firms in the services sector often reported that higher productivity reduces marginal cost, while e-commerce reduces the cost structure and increases efficiencies (i.e., e-commerce can increase a firm's sales volume without a proportionate increase in investment in space or labour, such as sales staff).

Most firms reported little or no direct impact on their output prices. The most common reason they cited was that lower costs result in wider margins (as opposed to lower sales prices). The second-most-common reason was that reductions in costs are offset by increased costs to adopt or maintain technology. Some argue that the adoption of new technologies is not meant to reduce costs; rather, objectives include increasing the top line, improving customer satisfaction and

[8] Statistics Canada aims to adjust prices for quality changes—an increase in prices due to improvements in quality could mean that the price of the unadjusted product is in fact decreasing (see Statistics Canada 2013, section 2.2.1). That said, quality changes can be difficult to measure and take time to show in CPI statistics. For instance, while quality changes such as digital options integrated into a good can be accounted for in the CPI based on a cost-estimate approach, this is more difficult in the case of digital services attached to a good. Moreover, it may take several years before new digital products are included in the CPI calculation.

differentiating the firm from competitors. Others expect that price effects will surface only beyond the three-year horizon of the survey question. Still others (such as firms operating in price-regulated or commodity markets) expect that prices will remain unaffected altogether.

Aggregate results mask distinct responses by firm size (**Chart 2**).[9] Small firms anticipate that higher costs will put upward pressure on their prices over the next three years. In addition, we find that small firms in our sample are, on average, less likely to adopt digital technologies, and only a handful of small firms reported efficiency gains that can be passed through to final prices. These results are consistent with prior research and reports indicating that small and medium-sized firms face higher barriers to entry because of resource constraints (ICTC 2019; Thomas 2016; Ghobakhloo et al. 2011; Prause 2019) and that small and medium-sized firms are less likely to realize cost savings (Riquelme 2002).

In contrast, large firms expect, on net, a slight disinflationary price effect from technology. Large firms most often reported lowering their prices in response to technology-enabled cost reductions, the most prominent reason being efficiency gains. Given that large firms are also the highest adopters of technology in our sample, these results suggest that these firms may have overcome the installation phase (Van Ark 2016) and are in the deployment phase that allows, at the margin, lower prices.[10] Large firms may also be in a better position to realize cost savings (with presumably more people and processes that could be replaced) or to improve productivity through technology.[11]

1.3 Indirect impacts on prices

Digital technologies may affect prices beyond firm-specific changes, such as by altering the supply chain, increasing online competition, or changing consumer or customer habits and needs. Because these technologies may have impacts that reach beyond an individual firm, we asked all

[9] When presenting Canadian and global survey results, we categorize small firms as those with 50 or fewer employees, medium-sized firms as those with 51 to 250 employees and large firms as those with more than 250 employees. These size categories were adopted to maximize the number of observations we could use globally and to give a fairly equal share of firms by size in the global results.

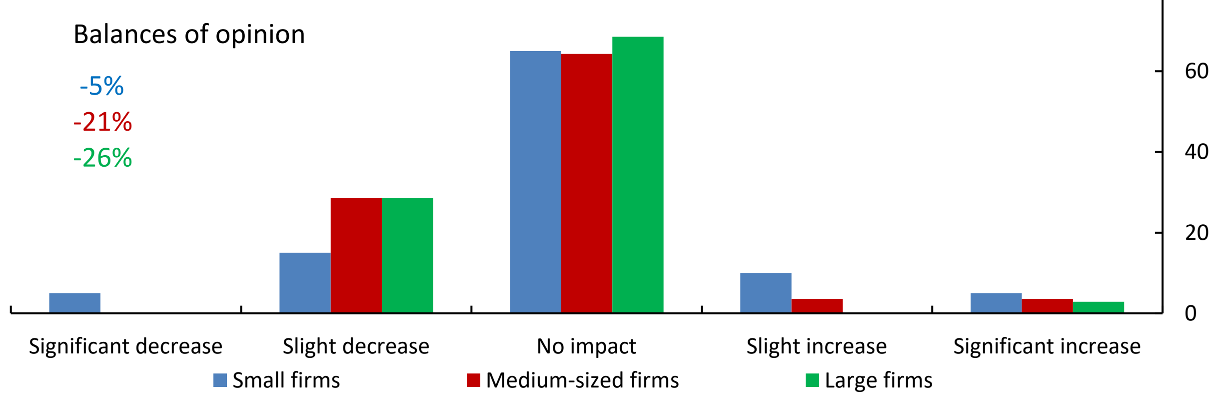
[10] Note that in some cases these lower prices are offset by higher costs or improved margins rather than being passed on to their clients.

[11] The literature argues that not only is it easier for large firms to invest in digital technologies (e.g., because they have the resources, financial means and access to equity financing and government funding programs and can more easily attract highly skilled specialists), but they also have a higher capacity to reap the returns (because of economies of scale and scope and the ability to spread risks over a portfolio of projects). See Innovation Policy Platform and Dimick (2014).

firms about how their prices were affected by the adoption of technologies by competitors, suppliers and customers, whether or not they themselves adopted any technologies.

Results from the BOS suggest that, on balance, firms expect a net disinflationary effect (a balance of opinion of -19 percent). Downward pressure on prices is attributed mainly to intensified competition from competitors adopting technology, particularly e-commerce, as well as to lower costs from suppliers or customers adopting technology. Upward indirect pressure comes mostly from better products from suppliers or competitors leading to higher prices. Most firms expect little or no impact on prices because they sell products that are less prone to competition (e.g., niche products) or because it is too early for prices to adjust. Firms also said it is difficult to pin down the effect of indirect pressures because the factors at play can offset one another.

Chart 3: Compared with smaller firms, large firms expect a more negative indirect impact on prices



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

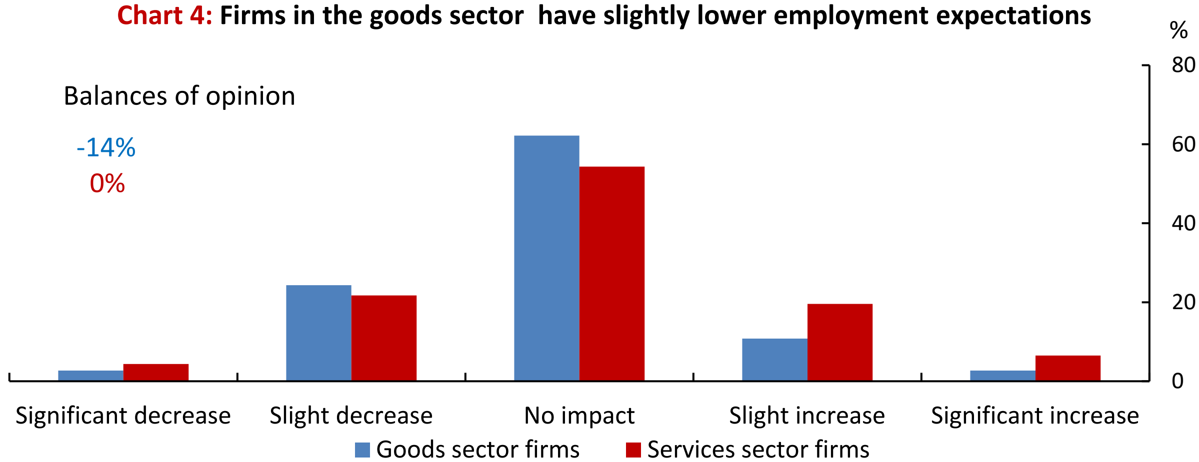
Distinct results by firm size are more evident for the indirect effects on prices, as large and medium-sized firms, on balance, reported a clear disinflationary impact (**Chart 3**). There are several possible reasons for this result. First, research suggests that small firms are less likely to compete on price, particularly against large firms (Audretsch, Prince and Thurik 1999). Compared with small firms, large firms in our sample may be more likely to compete on price against other large firms, with technology adoption by large firms' competitors mainly tied to reducing industry costs and therefore prices. Second, the Bank's regular complementary industry consultations suggest that some large firms in highly competitive markets exercise the strength of their bargaining position within the supply chain to garner reductions in supply prices—an influence smaller firms could not exert. This is an example of cost savings from digital adoption resulting in lower prices that get pushed upstream in the supply chain.

1.4 Impact on employment

The media and recent research have often predicted dramatic shifts in employment as digitalization allows firms to automate not only manual but also, increasingly, cognitive tasks.[12] We asked firms that reported being technology adopters about their expectations for the overall impact of adoption on the size of their workforce over the next three years.

Overall, firms surveyed in the BOS reported a small net negative effect on employment (a balance of opinion of -6 percent); this result is driven primarily by responses from firms in the goods sector (**Chart 4**). A number of firms expect an outright decline in the size of their workforce as a result of technology-induced automation or productivity gains. Others cite downward pressure on employment *growth*, not level, as employees become more efficient. Examples of labour saving include employing fewer sales staff as e-commerce reduces foot traffic in stores, replacing low-skilled employees (e.g., in farming) and streamlining back office tasks (e.g., legal, scheduling, client services, supervision and accounts payable). For some firms, automation alleviates pressures from labour shortages or minimum-wage increases.

Chart 4: Firms in the goods sector have slightly lower employment expectations



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey

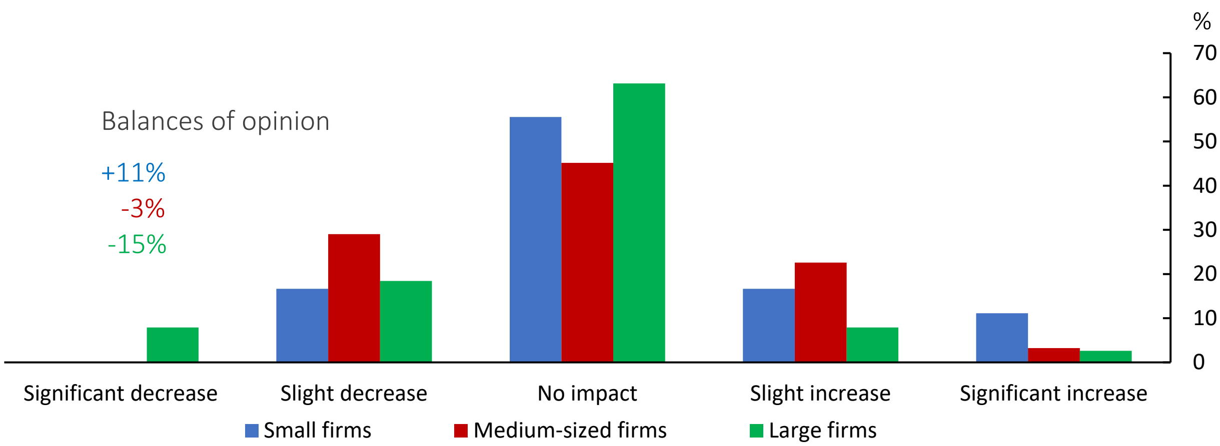
Last observation: 2018Q2

[12] For a summary of estimates, see Winick (2018).

However, negative effects are nearly offset by several firms having stronger hiring needs, most often for specialized labour to implement or maintain new technologies. For example, firms need digital talent to staff larger information technology departments, implement customer service tools on the cloud, manage social media, develop independent e-commerce sites, and innovate and create new products.

In addition, most firms reported little to no impact on the size of their workforce, noting instead changes to the composition of skills. Some said they adopt technology to grow their sales or their customer reach and service, with little impact on employment. Firms also anticipate effects likely beyond the three-year horizon. Taken together, the survey results provide little evidence of a large-scale digitally induced automation of employment, at least not in the near term.

Chart 5: Large firms expect technology to negatively impact employment



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

Large firms are more likely than small firms to expect a technology-related decline in employment over the next three years (**Chart 5**). For large firms, technology often replaces labour. And for large firms there are also scale effects. With more people and more processes, large firms have more room than small firms to reduce their number of employees through technology adoption. Finally, given the higher propensity of large firms to adopt technology, they may be further along in adoption where labour-replacing technologies are more likely to be fully operational. In contrast, for small firms, additional hiring to implement technology appears to be the dominant (or only) effect.

Section 2 | Global results

This section combines results for Canada with survey responses from 11 other central banks, allowing for comparisons across regions and analysis by firm characteristic on a much larger sample.[13] Overall, global results are consistent with key findings from the Canadian results. In particular, large firms are frontrunners on adoption and expect more disinflationary effects and more negative impacts on employment than small and medium-sized firms.

2.1 What characteristics determine technology adoption?

Using our global set of results, we can econometrically assess how firm characteristics (size, sector or region) influence the likelihood that a firm will adopt at least one technology. We evaluate the impact of each characteristic using a linear probability model (ordinary least squares) and assess the direction and significance of a characteristic for the likelihood of adoption relative to a base-case firm.

The drawback compared with a logit approach is that the estimated coefficients do not precisely determine the magnitude of those positive or negative impacts.[14] However, logit models are more sensitive to misspecification. Given the limited set of firm characteristics that can be used as explanatory variables for something as complex as the decision to adopt a certain technology, we opted for a linear probability model:

$$Adopt = \alpha + \beta(\mathrm{X}) + \mu, \tag{1}$$

where the dependent variable is a binary outcome (adopted at least one technology or not), and X is a vector of firm characteristics (size, sector, region and survey frame).

Results are in line with our expectations. Relative to large firms, small and medium-sized firms are less likely to adopt technology, with statistically significant coefficients. Regionally, it seems firms in Canada, Europe and the rest-of-the-world group are less likely to adopt technology relative to US firms.[15] Compared with firms in the primary sector, firms in all other sectors are more likely to adopt technology, but estimated coefficients are not significant. This mirrors our finding that

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[13] For a list of participants, see **Table A-1** in the Appendix.

[14] This is a consequence of the linear probability model not constraining the probability of adoption within the [0,1] bound as a logit or probit model would.

[15] The rest-of-the-world group includes Malaysia, Sri Lanka and Turkey.

adoption levels do not vary much by sector, although the types of technologies adopted are different.

Table 1: Results of the linear probability model

$$Adopt = \alpha + \beta(X) + \mu$$

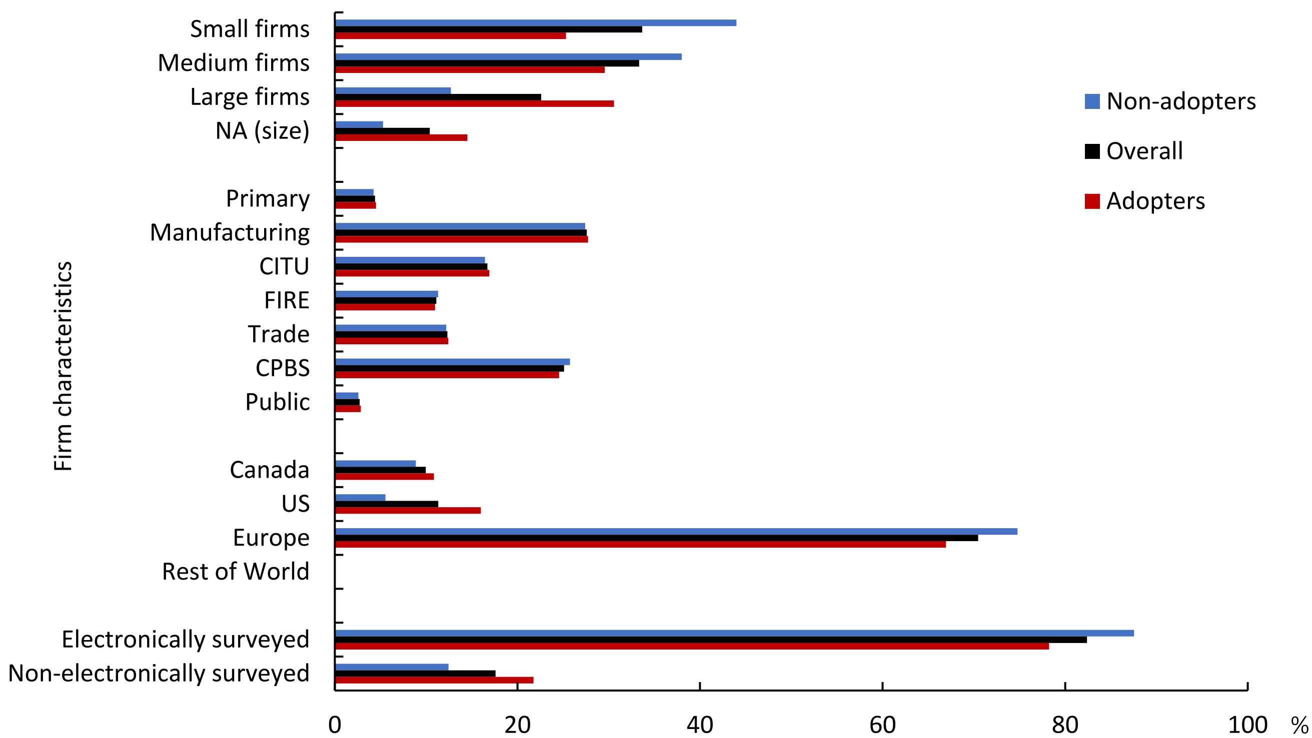
Characteristic (number of observations)	coefficient	*t*-statistic
Base case: Large firms (1367)		
Small (2037)	-0.355***	-19.62
Medium-sized (2017)	-0.240***	-14.00
Base case: United States (686)		
Canada (603)	-0.070**	-2.16
Europe (4263)	-0.261***	-9.68
Rest of the World (498)	-0.627***	-14.39
Base case: Primary sector (266)		
CITU (1011)	0.017	0.22
CPBS (1519)	0.089	1.17
FIRE (673)	0.113	1.37
Manu (1670)	0.118	1.57
Trade (746)	0.123	1.62
Public (165)	0.069	0.65
Base case: in-person/phone survey (1065)		
Online survey (4985)	-0.194	-6.11***

Note: Industry aggregates are defined by the North American Industry Classification System as follows: Primary (100 to 219); Manufacturing (300 to 339); Trade (410 to 479); Construction, information and cultural industries, transportation and utilities (CITU 220 to 239 and 480 to 519); Finance, insurance, real estate, and leasing (FIRE 520 to 539); Commercial, personal, and business services (CPBS >540).

We also find that firms surveyed electronically are less likely to report adopting technology. While this result is surprising, it may be explained by several factors. First, firms surveyed in person were able to ask interviewers whether a technology qualified. They could clarify definitions, making them more likely to report a technology as adopted. Second, firms surveyed in person might have wanted to appear more technologically sophisticated as a result of social desirability bias, a well-documented phenomenon in self-reporting surveys (Krumpal 2013). Finally, firms surveyed electronically might have spent less time considering responses; this reduces the likelihood a respondent will select a technology they are not sure has been adopted.

A sizable group of firms—2,705 or 45 percent—have not adopted any digital technologies. Relative to the overall sample, these firms are more likely to be small or medium-sized, to be from outside North America, and to have been surveyed electronically **(Chart 6)**. No sector has clearly different adoption rates.[16] While the short questionnaire did not investigate reasons for not adopting technology, previous analysis points to internal barriers for firms (e.g., lack of a digital strategy, difficulty estimating the benefit of a certain technology, staff or management resistance to change), the cost of technology amid limited investment budgets, and difficulties in finding the right talent (Dong, Fudurich and Suchanek 2017; Dimick 2014; Gray and Proulx 2017).

Chart 6: Shares of adopting and non-adopting firms differ notably only by firm size
n = 3,345 (adopting), 2,705 (non-adopting)



Note: CITU includes firms in the construction, information services, transportation and utilities industries. CPBS includes firms in commercial, personal and business services. FIRE includes firms in finance, insurance and real estate. Rest of World includes observations from Malaysia, Sri Lanka and Turkey.

Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

[16] It is important to note that these shares don't take into account the interaction among these variables. For example, small and medium-sized firms make up a larger share of electronically surveyed firms than of firms surveyed in person, while European firms were more likely to be surveyed electronically.

2.2 Methodology for testing differences: propensity score matching

Having assessed the importance of a firm's characteristics for adopting technology, we now want to compare response distributions across regions and other metrics. Comparing results between central banks is challenging because of the wide variation in sample composition (firm size and sectors) and survey modes (online or face to face). We thus use propensity score matching (PSM) to select comparable samples across regional groupings, sectors and firm size to account for such differences in samples (see Appendix A.3 for more information on PSM).

PSM has become an increasingly popular tool to determine causal effects when randomized experiments with proper treatment and control groups are not available. Working with treatment samples that have systematically different characteristics than control groups, many papers have used PSM when investigating the effect of treatment on outcomes (e.g., the impact of changes in capital-financial measures on macroeconomic variables, or the effects of participation in a workplace training program on earnings). Apart from "treatment effects," and similar to our paper, researchers also use PSM to create two comparable groups that may not be random but that would share the same characteristics, such that an unbiased comparison effect can be calculated.[17] In our case, we want to examine how the outcomes of firms surveyed electronically differ from the outcomes of firms surveyed in person. Without accounting for differences between firms surveyed elctronically and those surveyed in person, we could not determine the effect of being surveyed electronically.[18] We thus use PSM to first create comparable samples before testing for differences in outcomes.

Specifically, establishing comparable samples using PSM allows us to investigate two types of questions: First, we estimate whether *adoption rates* differ among groups in a statistically significant way. Second, we test whether *response distributions* on the questions about price and employment impact are statistically different between any two groups in terms of either the distribution or the mean. (We using the Kolmogorov–Smirnov test of the equality of distributions

[17] For instance, Forbes, Fratzscher and Straub (2015) and Pandey et al. (2015) use PSM to compare countries that use capital controls with those that do not.
[18] See Dehejia and Wahba (2002).

and the Wilcoxon rank-sum test, also called the Mann–Whitney *U* test.) Appendix A.3 provides more details of the estimation procedure.

In addition to adding the global set of results, we include in our statistical tests the results from our online consultation of 502 small Canadian businesses, which was part of a pilot electronic version of the BOS (e-BOS). The e-BOS sample, though less representative of GDP than the BOS, does include a much larger number of firms, giving more confidence in test results that compare Canadian with non-Canadian firms by increasing the sample size.

One important caveat in using PSM is that it requires meeting the conditional independence assumption (CIA)—that is, the outcome variable must be independent of treatment conditional on the propensity score, which is determined by our observed set of covariates. This is a strong assumption that is unlikely to be met: while post-estimation does point to a high degree of post-match balance across our covariates, the CIA also requires that we use all covariates that jointly determine treatment and outcome. Given our limited set of covariates to use in PSM, it is unlikely that we account for all possible determinants. We are therefore cautious in interpreting our results as pure treatment effects and instead prefer to interpret our test results as indications of differences between two groups that may be attributed to unobservable characteristics.

2.3 Adoption of digital technology

Several interesting insights emerge when we compare adoption rates across countries, firm sizes and sectors. In the following, we focus on statistically significant differences across certain groups of interest.

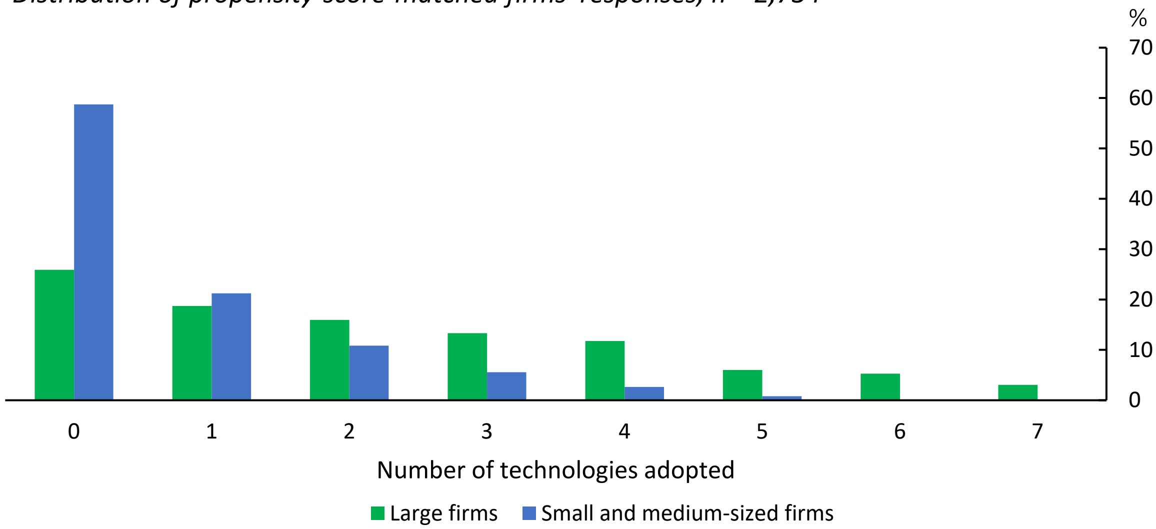
First, large firms show notably higher levels of adoption across all technologies. This result is consistent across almost all central bank surveys that report firm size. PSM reveals that, controlling for aggregate region, sector and survey mode, large firms are 28 percent more likely than small or medium-sized firms to have adopted at least one technology (**Table A-2**).[19, 20] **Chart 7** shows the distribution of propsensity-score-matched firms by number of technologies adopted: large firms

[19] This result was obtained using radius caliper matching, which yields favourable post-estimation results. Alternative estimators (e.g., the nearest neighbour) provide somewhat smaller estimates.
[20] If we look at individual technologies, large firms are more likely to adopt big data by 26 percent, cloud computing by 24 percent, Internet of Things by 21 percent, robotics by 19 percent, AI by 13 percent and 3-D printing by 11 percent.

more often reported adopting several technologies, while small and medium-sized firms (that are otherwise similar) frequently adopted only a few or none at all.

Chart 7: Small firms tend to adopt fewer technologies

Distribution of propensity-score-matched firms' responses, n = 2,734



Note: Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey | Last observation: 2018Q2

It appears that Canadian firms are marginally more likely to adopt at least one technology compared with most of their foreign counterparts that are otherwise similar (i.e., controlling for sector, firm size and survey mode). In particular, Canadian firms are somewhat ahead of European firms (9 percent more likely). US firms are heavier adopters than firms in other groups; they are 25 percent more likely to adopt than firms in the rest-of-the-world group and roughly 16 percent more likely than Canadian firms. These findings are consistent with results presented in section 2.1.

Certain sectors exhibit a higher adoption rate for certain technologies (**Table A-4** and **Table A-5**):

- Overall, firms in the services sector are strong adopters, particularly of e-commerce. This result is driven largely by trade sector firms, which are roughly 19 percent more likely than firms in other sectors to adopt e-commerce (**Table A-5**). This reflects retailers' shift to an increased use of online or multichannel selling strategies. This finding holds for all country groups except the rest-of-the-world group. Firms in commercial, personal and business services are ahead of other sectors in the adoption of AI (2 percent more likely), big data (4.6 percent) and cloud computing (11 percent). This could be the result of firms taking advantage of new possibilities for collecting information on their customers and competitors to better tailor products, advertisements and prices. Firms in finance, insurance and real estate are even more advanced in these technologies, showing 10 to 20 percent higher adoption rates (**Table A-5**).

- Not surprisingly, firms in the goods sector are more advanced in their adoption of 3-D printing, robotics and the Internet of Things than are firms in services that are otherwise similar (i.e., controlling for firm size, country grouping and survey mode). This result is driven largely by the manufacturing sector, which is 12 percent more likely to adopt robotics. Manufacturing firms are also 9.6 percent more likely to adopt 3-D printing and 2 percent more likely to adopt the Internet of Things (**Table A-5**).[21]

2.4 Direct impact on prices

Overall, global results suggest an overall slight positive direct impact on prices in most regions. Digital technologies enable firms to charge higher prices because they add digital value to products. However, this does not necessarily imply higher quality-adjusted prices as measured in price indices such as the Canadian CPI.

Balances of opinion are (marginally) positive in both goods and services sectors, with firms reporting that better products and implementation costs force prices up. Services firms more often said better customer data or price discrimination allows them to raise prices. For firms citing downward pressure, both goods and services cost savings are passed on to customers. Balances of opinion are slightly positive in nearly all sectors, most strongly in information and communication. PSM does not detect statistically significant differences across sectors with the exception of trade firms, which are less likely to report a positive impact. This is intuitive as trade firms have reportedly little pricing power and rely largely on price changes by competitors and changes in domestic (non-labour) inputs costs to determine their prices.[22]

We find no strong evidence that Canadian firms are statistically different from their peers around the world. In the United States, while several firms are passing on to customers the additional

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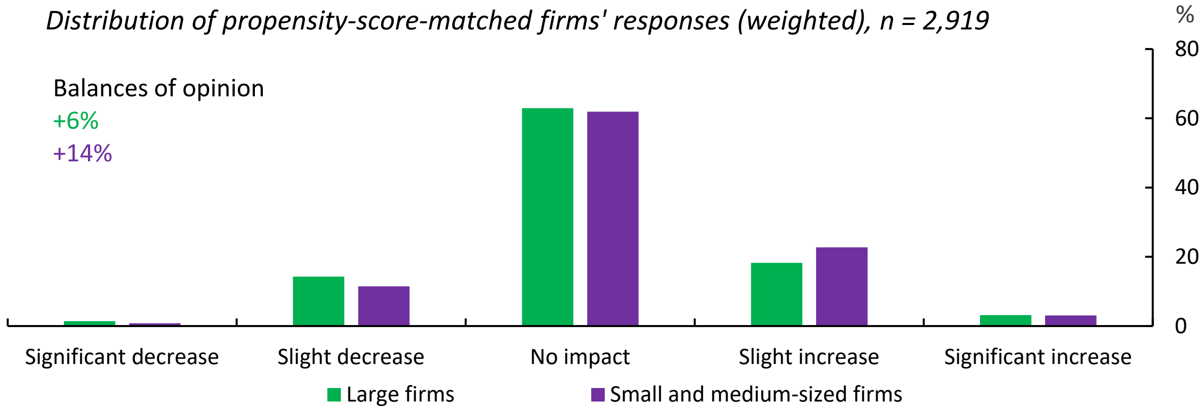
[21] Finally, construction, information, transportation and utilities firms (a category including both goods and services) appear to be lagging, being 4.7 percent less likely to have adopted at least one technology. In particular, they show a statistically significant lower propensity to adopt 3-D printing and robotics compared with firms in other sectors that are otherwise similar.
[22] See Amirault, Kwan and Wilkinson (2006).

costs of adopting and maintaining new technologies, some reported using big data for customer and sales analytics to better target their markets. This seems to be an opportunity most Canadian firms have not yet grasped. Generally, Canadian firms and firms outside Canada cited similar factors as underlying their reponses.

Aggregate results by firm size suggest that large firms expect less positive direct impacts on prices relative to small and medium-sized firms. However, following PSM, we find no clear evidence that those differences are significant (**Chart 8**).

Chart 8: Direct impact on prices does not vary significantly by firm size

Distribution of propensity-score-matched firms' responses (weighted), n = 2,919



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

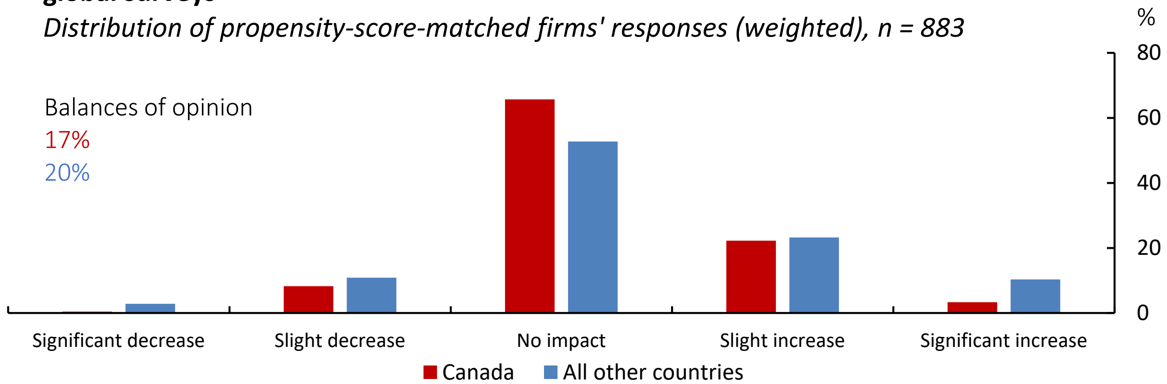
2.5 Indirect impacts on prices

The aggregate global results suggest there are offsetting indirect impacts.[23] This contrasts with BOS results, which point to a negative balance. This difference is largely explained by the fact that, compared with the survey samples from other countries, the BOS sample contains more large firms. When comparing propensity-score-matched firms—because PSM takes into account such differences in sample composition—we find that the distribution of responses from BOS firms does not differ significantly from that of non-Canadian firms (**Chart 9**).

[23] Four central banks did not ask this question, reducing the sample size to 1,505 firms.

Chart 9: Indirect impact on prices is qualitatively consistent across Canadian and global surveys

Distribution of propensity-score-matched firms' responses (weighted), n = 883



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

Matching, however, indicates that firms that have adopted at least one technology responded differently than firms that have not adopted any: while a similar share of adopting and non-adopting firms face negative indirect pressure, adopting firms more often reported negative indirect effects on their prices. This is driven by adopters of AI, big data, e-commerce and cloud computing (**Table A-7**). It is possible that firms using these technologies expose themselves to fiercer competition; for example, online selling makes the pricing of products vulnerable to rapid price comparison with competitors. These findings are in line with firms' narrative responses, which note that the indirect impacts on prices from e-commerce are almost universally on the downside. The results also corroborate findings from the Bank of Canada's 2017 special survey that highlighted the disinflationary impact of e-commerce in the wholesale, retail and logistics sectors through widening competition and increasing price transparency.[24]

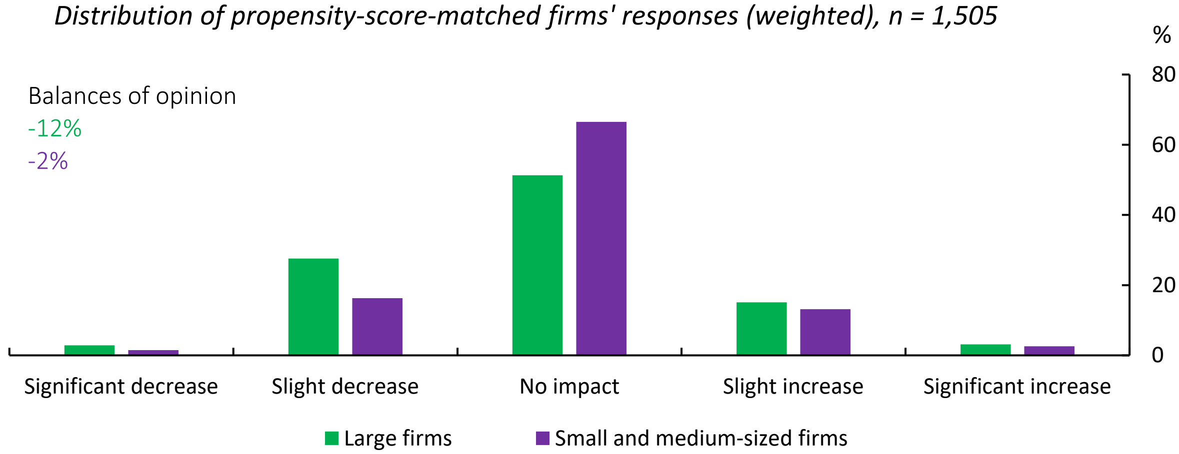
On balance globally, both goods and services sectors show similar, offsetting indirect impacts; but services firms more often referred to e-commerce and Amazon specifically. PSM analysis shows that prices in the trade sector, where adoption of e-commerce is strongest, do not appear to be significantly more affected than prices in other sectors. In Europe, trade firms reported being part of a highly competitive sector, where a widespread adoption of digital technologies forces firms to limit price increases to retain their market share.

[24] See Dong, Fudurich and Suchanek 2017.

Firms citing upward pressure on prices noted that investment in technology by competitors or suppliers would ultimately lead to higher prices through product differentiation or better price discrimination. Man y expect no change in their prices (including industry leaders and firms selling highly differentiated or niche products).

Chart 10: Indirect impact on prices: Large firm impacts tilted to deflationary, compared to inflationary for small and medium-sized firms

Distribution of propensity-score-matched firms' responses (weighted), n = 1,505



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Survey

Last observation: 2018Q2

In the case of indirect price effects, PSM suggests that the response distribution differs across firm size in a statistically significant way: large firms are much more likely than small and medium-sized businesses to report a disinflationary effect (**Chart 10** and **Table A-6**). This corroborates the results found using a much smaller sample of Canadian firms (section 1.3). As shown above, large firms not only are stronger adopters of digital technology but also may be more exposed to global competition than their small and medium-sized counterparts, resulting in more downward pressures on their selling prices.

2.6 Impacts on employment

Finally, firms were asked how technology adoption would affect the level of employment over the next three years. Results suggest a small negative impact, with 11 of 12 central bank surveys showing a negative balance. Many firms said they adopted technologies such as automation and robotics to replace low-skilled workers in order to lower their costs and improve efficiency. Indeed, PSM analysis confirms that the distribution of responses of firms adopting robotics differs significantly from that of non-adopters: adopting firms show a lower balance on employment (**Table A-7**). Employment effects for adopters of e-commerce are also significantly different (tilted more to the negative) than those for non-adopters that are otherwise similar (i.e., contolling for size, sector, region and survey mode) (**Table A-7**). This may be because efficiency gains from selling online outweigh additional needs for information technology staff.

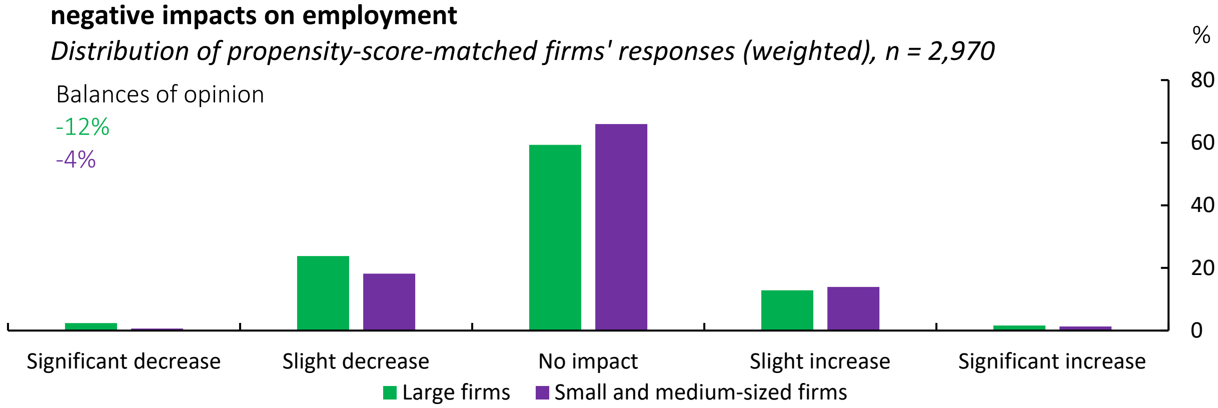
Balances of opinion are (marginally) negative in most sectors. Firms in the services sector often reported that selling online or providing services online reduces the need for staff (e.g., e-commerce reduces the need for sales staff, while online financial services reduce the need for branch staff). Firms in the goods sector reported that technology generally replaces staff or reduces employment growth. PSM does not detect statistically significant differences across sectors.

Firms citing higher employment also frequently noted that technology adoption boosted their sales volumes, leading to organic growth in staff. Several firms expect a shift in the composition of their workforce from low-skilled to high-skilled labour, through either retraining or replacing staff. Many respondents also indicated that the employment effects might be felt beyond the three-year horizon.

Finally, consistent with Canadian results, PSM reveals that large firms expect more negative impacts on employment than do small or medium-sized firms (**Chart 11**). This is also true in aggregate for almost all results by country.

Chart 11: Compared with small and medium-sized firms, large firms report more negative impacts on employment

Distribution of propensity-score-matched firms' responses (weighted), n = 2,970



Note: Balance of opinion indicates the percentage of firms expecting an increase in employment minus the percentage expecting a decrease. Excludes firms citing "don't know" and regions that did not report firm size.

Source: Bank of Canada Business Outlook Last observation: 2018Q2

Conclusion and policy implications

The implications of digitalization for firms' operations are far-reaching and complex, going beyond the metrics analyzed in this paper. However, some conclusions can be drawn from this first global survey initiative about the implications of digital technology adoption.[25]

Survey results show how adoption rates differ across countries, sectors and firm sizes. By allowing us to control for variation in sample composition, PSM shows that large firms are universally more advanced. Cross-regional comparisons point to more widespread adoption of technology in North America. Services firms are more focused on e-commerce, while firms in the goods sector, in particular manufacturing, lead on the adoption of 3-D printing, the Internet of Things and robotics.

Overall, firms expect that adopting technology will have little direct impact on prices because the effects resulting from cost efficiencies (e.g., from automation and labour-augmenting technologies) will be offset by some factors in the near term. Specifically, many firms, particularly small ones, see increased costs for implementation that must be passed on to their customers, while others said adding digital features to their product increases the sales price.

Reported indirect effects on output prices are roughly balanced. Firms, in particular those selling online, point to increased competition (via e-commerce) and cost pressures in the supply chain.

[25] For instance, the discussion of the implications of digitalization for market power and industry concentration, market structure, and new production technologies affecting returns to scale, to name but a few areas, are left for future work.

Large firms are also more likely to report disinflationary pressures through indirect channels. Some firms see higher prices from investment in technology in their industry, such as through product differentiation or better price discrimination. Qualitative survey results reveal complex effects that make it hard to pin down a net or even quantitative effect on prices. Responses from firms surveyed in the BOS tilted to a small negative indirect effect, consistent with previous findings that digital technology has a small disinflationary impact on prices.[26]

Results across countries point to a net negative impact on employment as a result of adopting labour-reducing technologies, in particular for adopters of e-commerce and robotics. Large firms, being more advanced, also more often report negative effects. This result holds across all country groupings. Such downward pressures are at least partially offset by the increased need to hire digital talent or other staff to accompany growth from adoption.[27] Of note, price and employment effects may take time to surface during or following adoption, beyond the three-year survey frame. Future work should explore more advanced methodologies (such as Bayesian hierarchical modelling) to further refine the comparison of datasets from different countries.

We draw some tentative implications for monetary policy. First, while several firms see no impact, for many businesses, especially large firms, digitalization clearly matters for price setting and hiring decisions. Further analysis is warranted to better grasp the implications of digitalization for the economy.[28] Second, the implications of digitalization for firms' pricing are multifaceted and in many cases offset one other. While results point to some downward pressure on prices for Canadian firms, policy-makers need to be aware of positive effects and how to interpret them. Firms report (digital) quality enhancements as an upward pressure; but because inflation statistics aim to account for such quality adjustments, survey results could overstate the inflationary impacts of digital technologies. It is important that policy-makers continue to monitor and analyze the impact of digital technology on those variables of interest.

[26] See Dong, Fudurich and Suchanek (2016 and 2017).

[27] Qualitative survey results support the argument that digitalization creates higher-value-added jobs. Digitalization may also create employment opportunities in new firms that are only partially reflected in survey results (Poloz 2018).

[28] Small firms, constituting a large share of employment in Canada, see limited or positive effects on both prices and employment. It is unclear whether this is a structural feature or whether we could expect small firms to follow their large peers and thus tilt the reported results in the near future.

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Appendix

A.1 Survey, sample composition and questionnaire

The Regional Analysis Division of the Canadian Economic Analysis Department of the Bank of Canada is an active player in the network of central bank business surveys and liaison programsthat conduct surveys.[29] In the second quarter of 2018, the network engaged in a collaborative effort, the first global survey initiative; 17 central banks participated.[30] The results reported in this paper cover the surveys from 12 central banks.

We collected more than 6,000 observations, with wide variation in sample sizes and industrial composition across the countries.[31] This makes comparing results by region difficult; and using statistical techniques (i.e., weighting) is not always possible because some central banks deliberately excluded small firms and some industries. Therefore, results are best analyzed by aggregating findings into region, size and sector categories and then using propensity score matching (PSM) to control for remaining differences in samples (see Appendix A.3).

Central banks were free to ask open-ended questions, and we collected narratives from individual firms only in the results for the Bank of Canada and the Federal Researve Bank of Atlanta. In addition, some regions provided summaries of their qualitative interview questions by theme. We may thus use the text data to support some of our hypotheses about why results differ by firm size and industry, but not to support hypotheses about results by region.

Table A-1: List of central banks that provided results for this paper

Participant	Regional aggregate	Number of observations
Bank of Canada	Canada	101 (BOS) + 502 (online)
Banca d'Italia	Europe	3,859
European Central Bank	Europe	74
Norges Bank	Europe	291
Sveriges Riksbank	Europe	39

[29] The nework, which includes almost 25 central banks, meets at an annual conference to share survey results that have implications for monetary policy, experiences in developing and implementing various approaches to gathering regional intelligence, and best practices in survey design and conduct.
[30] The questions are motivated by and based on the Bank of Canada's earlier survey on digital transformation in the services sector (Dong, Fudurich and Suchanek 2017). This survey focuses on the impact on firms' prices and employment.
[31] The Bank of Canada's in-person BOS sample is one of the most representative samples by industry.

Bank Negara Malaysia	Rest of the world	90
Central Bank of Sri Lanka	Rest of the world	45
Central Bank of the Republic of Turkey	Rest of the world	363
Federal Reserve Bank of Atlanta	United States	374
Federal Reserve Bank of Chicago	United States	92
Federal Reserve Bank of Philadelphia	United States	64
Federal Reserve Bank of Richmond	United States	156

Questionnaire

Firm characteristics:

- size: small (fewer than 50 employees); medium (50 to 250 employees); large (more than 250 employees)
- sector (two-digit NAICS code)
- country/region
- survey frame (electronic, in person or telephone)

Q1: Which of the following digital technologies, if any, has your firm adopted, including those you are in the process of adopting?

artificial intelligence
e-commerce
3-D printing
robotics
big data
cloud computing
internet of Things
other (please describe)
none of the above

Q2: **Direct impact on prices**—Overall, what impact do you expect your adoption of these technologies will have on the prices of your products/services over the next three years, if any?

significant increase
slight increase
little or no impact
slight decrease
significant decrease
unsure/don't know
[optional probe:] Please explain: _______

Q3: **Indirect impact on prices**—Overall, what impact do you expect the adoption of these technologies by others *in your industry (competitors, suppliers and customers)* will have on the prices of your products/services over the next three years, if any?

significant increase
slight increase
little or no impact
slight decrease
significant decrease
unsure/don’t know
[optional probe:] Please explain: _______

Q4: **Impact on employment**—Overall, what impact do you expect your adoption of these technologies will have on your number of employees over the next three years, if any?

significant increase
slight increase
little or no impact
slight decrease
significant decrease
unsure/don’t know
[Optional probe:] Please explain: _______

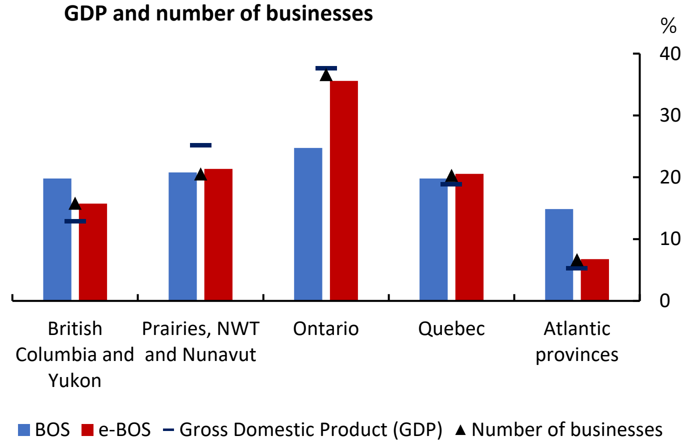
A.2 Composition of the Canadian sample

To complement the Business Outlook Survey (BOS), the Bank of Canada conducted a pilot online survey consultation, the e-BOS, from the second quarter of 2018 through the first quarter of 2019. During the final quarter of this online survey, the Bank also participated in the global survey intiative on digital adoption.[32]

The e-BOS pilot electronically surveyed approximately 500 firms. This sample was intended to be representative of the private sector economy, but the results were weighted to match region and industry shares of number of establishments rather than gross domestic product (GDP) (**Chart A-1** and **Chart A-2**). The e-BOS also excluded firms with more than 100 employees; these make up only 2 percent of firms but represent over half of GDP by firm size (**Chart A-3**).[33]

The BOS distribution of firms by region and industry is similar to the distribution of GDP with some overweighting in British Columbia and the Atlantic region, as well as in the manufacutring sector, contrasted with some underweighting in Ontario and the finance, insurance and real

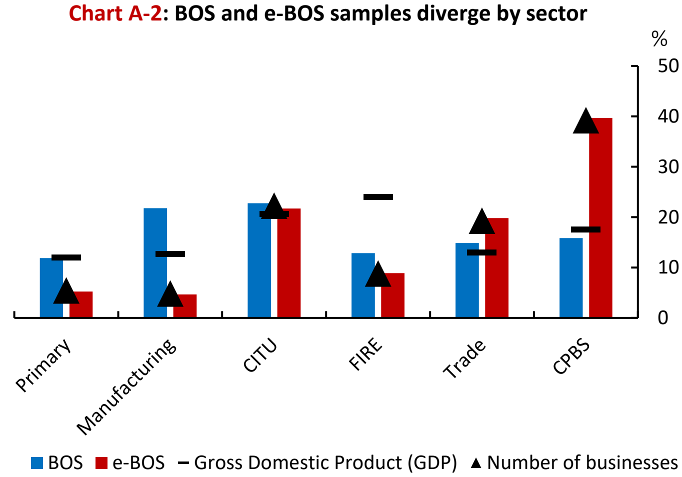
Chart A-1: Regional samples match distributions of GDP and number of businesses



Note: BOS and e-BOS refer to the regional sample distribution of the Business Outlook Survey and electronic Business Outlook Survey.

Sources: Bank of Canada Business Outlook Survey and Statistics Canada

Chart A-2: BOS and e-BOS samples diverge by sector



Note: BOS and e-BOS refer to the regional sample distribution of the Business Outlook Survey and electronic Business Outlook Survey. CITU include firms in the construction, information technology, transportation and utilities sectors. CPBS includes firms in commercial, personal and business services. FIRE includes firms in finance, insurance and real estate.

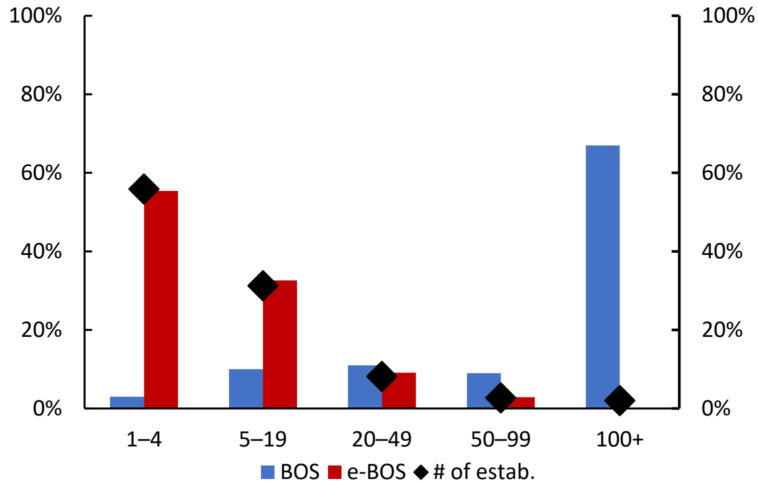
Sources: Bank of Canada Business Outlook Survey and Statistics Canada

[32] By design, the BOS rarely includes micro-firms or firms with fewer than 20 employees. These firms make up a large share of businesses by number of establishments (around 75 percent), but they contribute much less to overall GDP (less than 10 percent). Among other things, the e-BOS was intended to investigate responses to our BOS questionnaire from micro-firms and assess whether we are missing important signals to the economy by excluding this class of firms.

[33] Shares of firms by firm size can be found in Statistics Canada Table 33-10-0034-01. Share of GDP by firm size is calculated by Statistics Canada from 2002 to 2014. As of 2014, small businesses (1 to 99 employees) contributed 42 percent of Canada's GDP.

estate sector. The e-BOS is more closely aligned with the regional distribution of GDP and number of establishments, and is similarly representative of number of establishments by industry, which differs notably from GDP shares by industry.

Chart A-3: Most firms included in the BOS have over 100 employees



Note: BOS and e-BOS refer to the regional sample distribution of the Business Outlook Survey and electronic Business Outlook Survey.

Sources: Bank of Canada Business Outlook Survey and Statistics Canada

This appendix investigates to what extent the different survey modes and sample composition of the BOS and e-BOS matter for the results. Survey mode may bias results, particulary regarding technology adoption, in two ways. First, firms surveyed online may report lower adoption rates of technology if they are unsure about what some technologies are or what constitutes adoption. This can lead to an underreporting of some technologies.[34] Second, conducting the BOS survey in person could introduce a social desirability bias, causing firms to wish to appear more technologically advanced than they are. This could lead to an overreporting of technology adoption in some cases.[35] While both biases should result in higher reported adoption among BOS firms, firms of comparable size report similar adoption rates regardless of the survey mode. This suggests that overall the bias is small.[36]

To reduce the risk of including the same firm in both the in-person BOS and the online e-BOS, the latter targets only small firms—that is, firms with a maximum of 100 employees (and no minimum number). In contrast, two-thirds of the firms in the BOS sample have more than 100 employees, and no firm has fewer than 10. Overall, the e-BOS reports lower technology adoption rates (55 percent compared with 89 percent for the BOS on the question of adopting at least one technology). This is largely explained by lower adoption rates among small and micro firms (firms with fewer than 10 employees), which dominate the online survey. If we compare the results

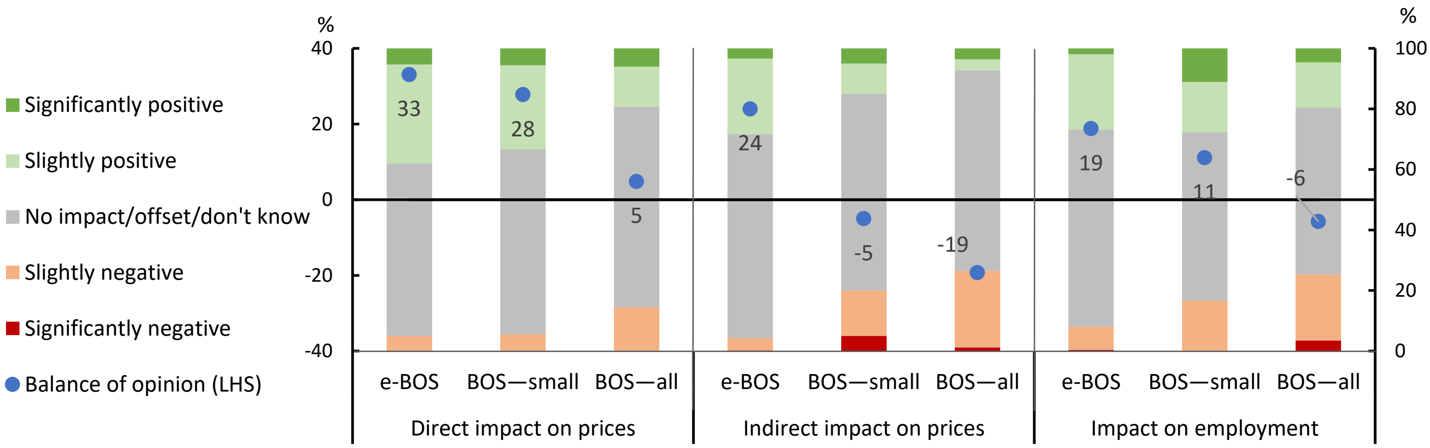
[34] Unlike the firms that were surveyed in person, online participants had no opportunity to clarify a technology definition.
[35] See Dillman, Smyth and Christian (2009).
[36] The shares of firms citing "unsure/don't know" in each sample frame are also similar, suggesting that survey mode has little impact.

obtained online with those for only small firms in the BOS, technology adoption rates are largely similar.

With these caveats in mind, results indicate that firms surveyed online reported more upward pressure on both prices and employment (**Chart A-4**). This is consistent with our key finding that small firms reported more upward pressure than did medium-sized or large firms. Accounting for differences in firm size (i.e., comparing the online sample with only small firms in the BOS), firms in both surveys reported similar impacts on prices and employment. While further work is needed to understand the reported differences in indirect price effects, they may be attributable to the smaller sample of small firms in the BOS (33 observations, compared with 502 firms surveyed online).

Chart A-4: Results from both the E-BOS and *small* firms in the BOS point to more upward pressure on prices and employment than in the BOS overall

Share of firms by firm size and survey frame



Note: BOS stands for Business Outlook Survey. E-BOS stands for pilot electronic version of the BOS. Direct impact on prices and impact on employment exclude firms with no technology adopted. Left side y-axis measures the balance of opinion. Right side y-axis measures the distribution of price and employment impacts.

Source: Bank of Canada Business Outlook Survey

A.3 Propensity score matching and statistical tests results

PSM allows us to compare results from two samples while taking into account different characteristics of the two samples. The participating central banks conducted their surveys using various sample compositions, including different firm sizes and sector representations, and different survey modes, such as online or in person.

Note that while PSM is traditionally used to identify a pure treatment effect, we instead use PSM to generate two comparable samples so that we can assess whether a firm characteristic (such as size or sector) influences the outcome of price or employment effects. This allows us to reduce the potential bias due to observable differences between the various surveys.[37] Using a radius caliper approach to PSM,[38] each firm in the group of interest (such as being part of the Bank of Canada sample, or being a large firm) is matched with a similar firm(s) in the control group based on proximity to its estimated propensity score. In fact, because our covariates are discrete and binary (size, sector, region, survey frame), there are a fixed number of discrete propensity scores based on different combinations of the covariates; choosing a small caliper then effectively ensures that firms in the group of interest are matched only with control group firms that share the exact same covariate data (i.e., the same propensity scores). Moreover, the methodology ensures that all observations in the control group sharing covariate characteristics with a firm in the group of interest are used. In practice, this means almost all observations are used, providing for balanced results. The propensity score is calculated using a probit model:

$$ps = prob(region = Canada|X = x),$$

where *x* is a set of observable controls of firm characteristics and of survey modes, which includes (in the example of Canadian firms) dummy varibles on firm size, sector and survey mode.[39] Given the dataset, we are unfortunately constrained in the number of controls we can use. While the literature is ambiguous regarding how many controls should be used,[40] our controls are theoretically founded and capture basic metrics that matter for the outcome variables (which are the basic criteria for inclusion; see Wyss et al. 2013 and Caliendo and Kopeinig 2008). As the matching produces balanced samples (see tables A-8 to A-16 in the Appendix), we are confident it is a sensible approach given the limitations of our dataset.

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[37] For instance, we can compare responses from Canadian firms (our treatment group) with firms of other countries, which will be treated as control groups, while controlling for differences in sample composition by firm size, sector and survey mode.

[38] While alternative matching techniques (e.g., nearest neighbour, kernel) yield similar results, radius caliper matching is the most appropriate technique because it consistently produces balanced groups while using almost all observations (see tables A-8 to A-16).

[39] The control variables vary with the dimension tested: testing differences on firm size, for instance, would use the control variables firm sector, survey mode and region.

[40] The literature does not specify a magic or minimum number of covariates or variables that affect the outcome (see Wyss et al. 2013). There are disadvantages from both the omission of important variables and the inclusion of too many variables.

Once we have two comparable samples, we use two different tests, depending on the variable of interest. First, to test whether a certain group is more or less likely to adopt a certain technology, we estimate the average treatment effect (ATE):

$$ATE = \bar{y}^1 - \bar{y}^0 ,$$

that is, the difference between the percentage of firms adopting in the group of interest $\bar{y}^1$ and the percentage of firms adopting in the matched control group $\bar{y}^0$. The test statistics determine whether the difference is statistically significant from zero and in which direction—that is, if adoption is higher or lower compared with the control group.

Table A-2: Adoption rates among large firms are universally higher

Treatment	Adoption of at least one technology	Artificial Intelligence	E-commerce	Cloud-computing	Internet of Things	Robotics	3-D printing	Big data
Large	0.224***	0.116***	0.123***	0.199***	0.166***	0.154***	0.106***	0.199***
	(0.0489)	(0.0295)	(0.0441)	(0.0446)	(0.0418)	(0.0351)	(0.0315)	(0.0366)
Observations	5,421	5,421	5,421	5,421	5,421	5,421	5,421	5,421

Standard errors are in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Note: Estimation using radius matching, average treatment effect, with replacement.

Table A-3: Adoption rates for Canadian (and US) firms are higher than those for European firms

VARIABLES	Canada vs. all other	Canada vs. United States	Canada vs. Europe	Canada vs. Rest of the World	United States vs. all other	United States vs. Canada	United States vs. Europe	United States vs. Rest of the World
Canada	0.0617***	-0.157***	0.0890***	0.489***				
	(0.0214)	(0.0257)	(0.0217)	(0.0525)				
United States					0.240***	0.157***	0.246***	0.373***
					(0.0200)	(0.0257)	(0.0202)	(0.0660)
Observa-tions	6,050	1,289	4,792	592	6,050	1,289	4,875	558

Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Note: Estimation using radius matching, average treatment effect, with replacement.

Table A-4: Adoption rates are higher for services firms due to higher adoption rates for big data, artificial intelligence, e-commerce and cloud computing

VARIABLES	Services vs. goods	Big data	Artificial Intelligence	E-commerce	Cloud computing	Internet of Things	Robotics	3-D printing
_treated	**0.0566*****	0.0652***	0.0367***	0.148***	0.113***	-0.0366***	-0.119***	-0.0976***
	(0.0129)	(0.00912)	(0.00724)	(0.0114)	(0.0117)	(0.0102)	(0.00904)	(0.00737)
Observations	**6,050**	6,050	6,050	6,050	6,050	6,050	6,050	6,050

Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1

Note: Estimation using radius matching, average treatment effect, with replacement.

Table A-5: Adoption rates of selected sectors

	Finance, insurance, real estate, and leasing (FIRE)					Trade	Manufacturing	
VARIABLES	FIRE vs. all other	Artificial Intelligence	Big data	E-commerce	Cloud computing	E-commerce	Robotics	3-D printing
_treated	0.166***	0.0967***	0.117***	0.201***	0.196***	0.192***	0.119***	0.0963***
	(0.0347)	(0.0194)	(0.0245)	(0.0309)	(0.0314)	(0.0165)	(0.00893)	(0.00728)
Observations	6,050	6,050	6,050	6,050	6,050	6,050	6,050	6,050

Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1

Note: Estimation using radius matching, average treatment effect, with replacement.

Second, to assess whether the distribution of responses to rating-scale questions (i.e., impact on prices and employment) is significantly different between groups, we use the Kolmogorov–Smirnov test and the Mann–Whitney *U* test [41] reported in Table A-6.

[41] The two-sample Kolmogorov–Smirnov test evaluates the equality of two distributions between a treatment group and a control group. The null hypothesis is that both samples are drawn from the same distribution, suggesting no treatment effect on the distribution. The Mann–Whitney *U* test (also known as the Wilcoxon rank-sum test) is a non-parametric *t*-test to evaluate whether two independent samples can reasonably be said to be drawn from the same distribution. The null hypothesis similarly assumes that both samples have the same distribution, in that a randomly selected observation from one sample is equally likely to be greater or smaller than a randomly selected observation from the second sample.

Table A-6: Selected Kolmogorov–Smirnov and Mann–Whitney *U* test results for impact questions comparing large vs. small and medium-sized firms and Canadian vs. other firms

Sample	Question	Treatment	KS test statistic[42]	MWU test statistic
All firms	Direct impact on prices	Large	0.044	2.708***
All firms	Indirect impact on prices	Large	0.142***	2.771***
All firms	Impact on employment	Large	0.061*	1.986**
All firms	Direct impact on prices	Canada	0.083	-2.620***
All firms	Indirect impact on prices	Canada	0.078	1.359
All firms	Impact on employment	Canada	0.118**	-4.334***

* indicates rejection of null hypothesis at the 90% level
** indicates rejection of null hypothesis at the 95% level
*** indicates rejection of null hypothesis at the 99% level

Table A-7: Selected Kolmogorov–Smirnov and Mann–Whitney *U* test results for impact questions comparing adoption status

Sample	Question	Treatment	KS test statistic[41]	MWU test statistic
All firms	Indirect impact on prices	E-commerce adopters	0.1079***	1.242
All firms	Impact on employment	E-commerce adopters	0.0568**	2.376**
All firms	Impact on employment	Robotics adopters	0.1212***	5.013***

* indicates rejection of null hypothesis at the 90% level
** indicates rejection of null hypothesis at the 95% level
*** indicates rejection of null hypothesis at the 99% level

Though not reported in this paper, we also test whether the survey frame (electronic vs. in-person or telephone) affects the distribution of responses to the questions on the impact technology. The treatment group is firms that were surveyed electronically, and firms are matched according to size, sector and regional aggregate. Results for the global sample suggest that firms surveyed electronically are marginally less likely to adopt technologies; however, differences are not statistically significant for the Canadian subsample. A comparison of the response distributions

[42] Rejection of the null hypothesis is based on *p*-values calculated from the reported combined Kolmogorov–Smirnov test statistic. The Kolmogorov–Smirnov test is applied to a modified set of results that reflect weights applied to control group observations following the caliper radius approach to PSM.

indicates that a slightly smaller share of electronic firms reported negative or disinflationary impacts, and a slightly larger share reported positive or inflationary impacts. We may be detecting an impact from other, unobservable, characteristics as well. This is because values are missing for some firm characteristics, results are aggraggated by region and sector, and further control variables are lacking.

Main balancing test results

Table A-8: Balancing test results: large vs. others—adoption status

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
Canada	U	.03072	.13838	-39.4		-11.07	0.000	.
	M	.03148	.02483	2.4	93.8	1.04	0.299	.
US	U	.13168	.06364	23.1		8.03	0.000	.
	M	.13343	.14537	-4.0	82.5	-0.89	0.374	.
Europe	U	.6335	.7479	-24.9		-8.19	0.000	.
	M	.63268	.6274	1.2	95.4	0.28	0.778	.
electronic	U	.70739	.92995	-60.3		-22.40	0.000	.
	M	.72489	.73154	-1.8	97.0	-0.39	0.699	.
CITU	U	.17996	.11075	19.7		6.64	0.000	.
	M	.18441	.1716	3.6	81.5	0.86	0.388	.
CPBS	U	.1368	.14603	-2.6		-0.84	0.400	.
	M	.14018	.16344	-6.7	-151.9	-1.67	0.094	.
FIRE	U	.04316	.02738	8.6		2.90	0.004	.
	M	.04423	.04176	1.3	84.4	0.31	0.754	.
Manu	U	.46013	.54859	-17.8		-5.68	0.000	.
	M	.46477	.46655	-0.4	98.0	-0.09	0.927	.
Primary	U	.00585	.00789	-2.5		-0.76	0.446	.
	M	.00375	.00197	2.2	12.9	0.86	0.390	.
Trade	U	.14484	.13863	1.8		0.57	0.567	.
	M	.13943	.13219	2.1	-16.6	0.55	0.585	.

* if variance ratio outside [0.90; 1.11] for U and [0.90; 1.11] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.120	733.36	0.000	20.1	18.7	83.7*	1.01	.
Matched	0.002	6.20	0.798	2.6	2.1	9.6	1.02	.

* if B>25%, R outside [0.5; 2]

Table A-9: Balancing test results: Canadian vs. US firms—adoption status

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
small	U	.80597	.19388	154.7		27.71	0.000	.
	M	.80467	.80801	-0.8	99.5	-0.15	0.884	.
medium	U	.12438	.18222	-16.1		-2.87	0.004	.
	M	.12521	.13135	-1.7	89.4	-0.32	0.751	.
large	U	.06965	.26239	-53.6		-9.45	0.000	.
	M	.07012	.06064	2.6	95.1	0.66	0.507	.
electronic	U	.8325	.90962	-23.1		-4.18	0.000	.
	M	.83806	.85088	-3.8	83.4	-0.61	0.541	.
CITU	U	.21227	.13557	20.3		3.66	0.000	.
	M	.21369	.21526	-0.4	98.0	-0.07	0.947	.
CPBS	U	.34826	.15743	45.0		8.12	0.000	.
	M	.35058	.38957	-9.2	79.6	-1.40	0.163	.
FIRE	U	.0796	.18367	-31.1		-5.52	0.000	.
	M	.08013	.08013	0.0	100.0	0.00	1.000	.
Manu	U	.07131	.22157	-43.5		-7.68	0.000	.
	M	.06511	.05563	2.7	93.7	0.69	0.491	.
Primary	U	.0199	.00875	9.4		1.70	0.089	.
	M	.02003	.00955	8.8	6.0	1.50	0.133	.
Trade	U	.1592	.11662	12.4		2.22	0.026	.
	M	.16027	.16226	-0.6	95.3	-0.09	0.925	.

* if variance ratio outside [0.85; 1.17] for U and [0.85; 1.17] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.432	769.31	0.000	40.9	27.1	157.7*	0.04*	.
Matched	0.004	5.96	0.744	3.1	2.2	14.1	1.42	.

* if B>25%, R outside [0.5; 2]

Table A-10: Balancing test results: services

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
Canada	U	.18016	.04023	45.8		18.46	0.000	.
	M	.18016	.18252	-0.8	98.3	-0.22	0.826	.
US	U	.18638	.05948	39.4		15.70	0.000	.
	M	.18638	.18402	0.7	98.1	0.22	0.827	.
Europe	U	.53696	.80718	-60.1		-23.52	0.000	.
	M	.53696	.53696	0.0	100.0	-0.00	1.000	.
small	U	.35953	.31983	8.4		3.23	0.001	.
	M	.35953	.35953	0.0	100.0	-0.00	1.000	.
medium	U	.27315	.37787	-22.5		-8.59	0.000	.
	M	.27315	.2608	2.7	88.2	1.00	0.317	.
large	U	.2463	.21092	8.4		3.26	0.001	.
	M	.2463	.25861	-2.9	65.2	-1.02	0.310	.
electronic	U	.80117	.8408	-10.4		-4.01	0.000	.
	M	.80117	.81584	-3.8	63.0	-1.34	0.181	.

* if variance ratio outside [0.93; 1.08] for U and [0.93; 1.08] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.084	695.65	0.000	27.9	22.5	70.2*	2.27*	.
Matched	0.001	6.99	0.430	1.6	0.8	7.4	1.06	.

* if B>25%, R outside [0.5; 2]

Table A-11: Balancing test results: Canada vs. not Canada—direct impact on prices

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
electronic	U	.76012	.86333	-26.6		-4.98	0.000	.
	M	.74286	.74286	0.0	100.0	-0.00	1.000	.
size_s	U	.71387	.2427	106.9		18.76	0.000	.
	M	.68889	.68889	0.0	100.0	0.00	1.000	.
size_m	U	.1763	.37111	-44.7		-7.13	0.000	.
	M	.19048	.19048	0.0	100.0	-0.00	1.000	.
size_l	U	.10983	.38619	-67.5		-10.21	0.000	.
	M	.12063	.12063	0.0	100.0	0.00	1.000	.
size_na	U	0	0	.		.	.	.
	M	0	0	.	.	.	.	.
sector_CITU	U	.21676	.11333	28.1		5.35	0.000	.
	M	.2381	.2381	-0.0	100.0	-0.00	1.000	.
sector_CPBS	U	.33237	.12646	50.5		9.96	0.000	.
	M	.36508	.36508	0.0	100.0	0.00	1.000	.
sector_FIRE	U	.07803	.04232	15.0		2.89	0.004	.
	M	.08571	.08571	-0.0	100.0	0.00	1.000	.
sector_Manu	U	.08382	.55982	-118.3		-17.38	0.000	.
	M	.09206	.09206	0.0	100.0	-0.00	1.000	.
sector_Primary	U	.02312	.00486	15.6		3.65	0.000	.
	M	.01905	.01905	0.0	100.0	0.00	1.000	.
sector_Trade	U	.16185	.14591	4.4		0.77	0.440	.
	M	.17778	.17778	0.0	100.0	0.00	1.000	.
sector_Public	U	0	0	.		.	.	.
	M	0	0	.	.	.	.	.

* if variance ratio outside [0.81; 1.24] for U and [0.80; 1.25] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.373	739.54	0.000	47.8	36.4	187.1*	0.56	.
Matched	0.000	0.00	1.000	0.0	0.0	-126.7	0.18*	.

* if B>25%, R outside [0.5; 2]

Table A-12: Balancing test results: large vs. not large—direct impact on prices

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
electronic	U	.67485	.79893	-28.5		-7.23	0.000	.
	M	.68527	.68527	-0.0	100.0	-0.00	1.000	.
Canada	U	.04444	.14922	-36.0		-8.06	0.000	.
	M	.04513	.04513	0.0	100.0	0.00	1.000	.
US	U	.19298	.17781	3.9		0.97	0.334	.
	M	.19359	.19359	0.0	100.0	0.00	1.000	.
Europe	U	.64327	.62064	4.7		1.15	0.250	.
	M	.64014	.64014	-0.0	100.0	-0.00	1.000	.
ROW	U	.1193	.05233	24.1		6.42	0.000	.
	M	.12114	.12114	0.0	100.0	-0.00	1.000	.
sector_CITU	U	.16491	.10417	17.9		4.58	0.000	.
	M	.16746	.16746	0.0	100.0	0.00	1.000	.
sector_CPBS	U	.12865	.13663	-2.3		-0.57	0.565	.
	M	.11758	.11758	0.0	100.0	0.00	1.000	.
sector_FIRE	U	.05848	.04409	6.5		1.65	0.099	.
	M	.05938	.05938	0.0	100.0	0.00	1.000	.
sector_Manu	U	.43509	.48401	-9.8		-2.41	0.016	.
	M	.44181	.44181	-0.0	100.0	-0.00	1.000	.
sector_Primary	U	.00819	.01502	-6.4		-1.48	0.138	.
	M	.00594	.00594	0.0	100.0	0.00	1.000	.
sector_Trade	U	.16257	.12645	10.3		2.58	0.010	.
	M	.16508	.16508	0.0	100.0	0.00	1.000	.
sector_Public	U	.0269	.01308	9.9		2.62	0.009	.
	M	.02732	.02732	0.0	100.0	0.00	1.000	.

* if variance ratio outside [0.87; 1.14] for U and [0.87; 1.14] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.069	242.23	0.000	13.4	9.9	64.1*	0.55	.
Matched	0.000	0.00	1.000	0.0	0.0	0.0	1.00	.

* if B>25%, R outside [0.5; 2]

Table A-13: Balancing test results: Canada vs. not Canada—indirect impact on prices

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
electronic	U	.834	.47566	81.3		13.00	0.000	.
	M	.8196	.8196	0.0	100.0	0.00	1.000	.
size_s	U	.798	.16105	165.3		26.60	0.000	.
	M	.77951	.77951	0.0	100.0	0.00	1.000	.
size_m	U	.132	.23034	-25.7		-4.12	0.000	.
	M	.14254	.14254	-0.0	100.0	-0.00	1.000	.
size_l	U	.07	.60861	-138.2		-22.00	0.000	.
	M	.07795	.07795	-0.0	100.0	-0.00	1.000	.
size_na	U	0	0	.		.	.	.
	M	0	0	.	.	.	.	.
sector_CITU	U	.234	.20599	6.8		1.09	0.277	.
	M	.26058	.26058	0.0	100.0	0.00	1.000	.
sector_CPBS	U	.342	.18165	37.1		5.98	0.000	.
	M	.38085	.38085	0.0	100.0	0.00	1.000	.
sector_FIRE	U	.082	.15918	-23.8		-3.81	0.000	.
	M	.09131	.09131	-0.0	100.0	-0.00	1.000	.
sector_Manu	U	.068	.24345	-49.8		-7.94	0.000	.
	M	.07572	.07572	-0.0	100.0	-0.00	1.000	.
sector_Primary	U	.016	.00936	5.9		0.96	0.339	.
	M	.00668	.00668	-0.0	100.0	-0.00	1.000	.
sector_Trade	U	.152	.17603	-6.5		-1.04	0.298	.
	M	.16927	.16927	-0.0	100.0	-0.00	1.000	.
sector_Public	U	0	0	.		.	.	.
	M	0	0	.	.	.	.	.

* if variance ratio outside [0.84; 1.19] for U and [0.83; 1.20] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.383	548.50	0.000	54.0	31.4	184.0*	0.77	.
Matched	0.000	0.00	1.000	0.0	0.0	-0.0	1.00	.

* if B>25%, R outside [0.5; 2]

Table A-14: Balancing test results: large vs. not large—indirect impact on prices

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
electronic	U	.30469	.68421	-82.0		-13.83	0.000	.
	M	.31967	.31967	0.0	100.0	-0.00	1.000	.
Canada	U	.09115	.41481	-80.2		-12.17	0.000	.
	M	.09563	.09563	0.0	100.0	0.00	1.000	.
US	U	.40625	.32471	17.0		2.91	0.004	.
	M	.42077	.42077	0.0	100.0	0.00	1.000	.
Europe	U	.26563	.22658	9.1		1.55	0.120	.
	M	.24863	.24863	0.0	100.0	0.00	1.000	.
ROW	U	.23698	.0339	62.1		12.92	0.000	.
	M	.23497	.23497	-0.0	100.0	0.00	1.000	.
sector_CITU	U	.22917	.16057	17.4		3.04	0.002	.
	M	.24044	.24044	-0.0	100.0	-0.00	1.000	.
sector_CPBS	U	.10677	.21142	-28.9		-4.59	0.000	.
	M	.08197	.08197	0.0	100.0	0.00	1.000	.
sector_FIRE	U	.1276	.09188	11.4		2.01	0.045	.
	M	.13388	.13388	0.0	100.0	0.00	1.000	.
sector_Manu	U	.2474	.20339	10.5		1.81	0.070	.
	M	.25956	.25956	-0.0	100.0	-0.00	1.000	.
sector_Primary	U	.01823	.02498	-4.6		-0.76	0.449	.
	M	.01366	.01366	0.0	100.0	0.00	1.000	.
sector_Trade	U	.17969	.12667	14.7		2.59	0.010	.
	M	.18852	.18852	0.0	100.0	0.00	1.000	.
sector_Public	U	.0625	.0223	20.0		3.85	0.000	.
	M	.06011	.06011	0.0	100.0	0.00	1.000	.

* if variance ratio outside [0.82; 1.22] for U and [0.81; 1.23] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.283	482.92	0.000	29.8	17.2	146.0*	0.50*	.
Matched	-0.000	-0.00	1.000	0.0	0.0	0.0	1.00	.

* if B>25%, R outside [0.5; 2]

Table A-15: Balancing test results: Canada vs. not Canada—impact on employment

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
electronic	U	.75	.86015	-28.1		-5.28	0.000	.
	M	.73248	.73248	0.0	100.0	-0.00	1.000	.
size_s	U	.70977	.23755	107.2		18.97	0.000	.
	M	.68471	.68471	0.0	100.0	-0.00	1.000	.
size_m	U	.18103	.37117	-43.5		-6.98	0.000	.
	M	.19427	.19427	-0.0	100.0	-0.00	1.000	.
size_l	U	.1092	.39128	-68.8		-10.43	0.000	.
	M	.12102	.12102	-0.0	100.0	0.00	1.000	.
size_na	U	0	0	.		.	.	.
	M	0	0	.	.	.	.	.
sector_CITU	U	.21264	.11207	27.5		5.25	0.000	.
	M	.23567	.23567	-0.0	100.0	0.00	1.000	.
sector_CPBS	U	.31609	.12739	46.6		9.17	0.000	.
	M	.35032	.35032	0.0	100.0	-0.00	1.000	.
sector_FIRE	U	.08046	.03879	17.6		3.49	0.000	.
	M	.08917	.08917	-0.0	100.0	-0.00	1.000	.
sector_Manu	U	.08908	.56657	-118.1		-17.49	0.000	.
	M	.09873	.09873	-0.0	100.0	-0.00	1.000	.
sector_Primary	U	.02586	.00431	17.7		4.36	0.000	.
	M	.01911	.01911	-0.0	100.0	0.00	1.000	.
sector_Trade	U	.16667	.14416	6.2		1.10	0.273	.
	M	.18471	.18471	0.0	100.0	-0.00	1.000	.
sector_Public	U	0	0	.		.	.	.
	M	0	0	.	.	.	.	.

* if variance ratio outside [0.81; 1.23] for U and [0.80; 1.25] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.382	763.03	0.000	48.1	35.8	189.6*	0.57	.
Matched	-0.000	-0.00	1.000	0.0	0.0	0.0	1.00	.

* if B>25%, R outside [0.5; 2]

Table A-16: Balancing test results: large vs. not large—impact on employment

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
electronic	U	.6754	.79015	-26.1		-6.69	0.000	.
	M	.68634	.68634	-0.0	100.0	-0.00	1.000	.
Canada	U	.04328	.14818	-36.2		-8.20	0.000	.
	M	.04398	.04398	0.0	100.0	0.00	1.000	.
US	U	.18109	.16491	4.3		1.07	0.284	.
	M	.18171	.18171	0.0	100.0	0.00	1.000	.
Europe	U	.65604	.63289	4.8		1.20	0.231	.
	M	.65278	.65278	-0.0	100.0	-0.00	1.000	.
ROW	U	.11959	.05402	23.4		6.29	0.000	.
	M	.12153	.12153	0.0	100.0	0.00	1.000	.
sector_CITU	U	.16743	.09847	20.4		5.32	0.000	.
	M	.17014	.17014	0.0	100.0	0.00	1.000	.
sector_CPBS	U	.1287	.1348	-1.8		-0.45	0.655	.
	M	.1169	.1169	0.0	100.0	0.00	1.000	.
sector_FIRE	U	.05011	.04302	3.4		0.85	0.396	.
	M	.05093	.05093	0.0	100.0	0.00	1.000	.
sector_Manu	U	.44077	.48805	-9.5		-2.36	0.019	.
	M	.44792	.44792	-0.0	100.0	-0.00	1.000	.
sector_Primary	U	.00797	.01482	-6.5		-1.51	0.130	.
	M	.00579	.00579	0.0	100.0	0.00	1.000	.
sector_Trade	U	.16515	.12476	11.5		2.93	0.003	.
	M	.16782	.16782	0.0	100.0	0.00	1.000	.
sector_Public	U	.0262	.01912	4.8		1.22	0.222	.
	M	.02662	.02662	0.0	100.0	0.00	1.000	.

* if variance ratio outside [0.88; 1.14] for U and [0.88; 1.14] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.068	243.64	0.000	12.7	8.0	63.4*	0.53	.
Matched	0.000	0.00	1.000	0.0	0.0	72.4*	0.84	.

* if B>25%, R outside [0.5; 2]