Organisation for Economic Co-operation and Development

ECO/WKP(2022)31

Unclassified

English - Or. English

13 October 2022

ECONOMICS DEPARTMENT

DOES FASTER INTERNET INCREASE EXPORTS? EVIDENCE FROM NEW ZEALAND

ECONOMICS DEPARTMENT WORKING PAPERS No. 1730

By Lynda Sanderson, Garrick Wright-McNaughton and Naomitsu Yashiro

All Economics Department Working Papers are available at www.oecd.org/eco/workingpapers.

JT03504891

The results in this paper are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) and or Longitudinal Business Database (LBD) which are carefully managed by Stats NZ. For more information about the IDI and LBD please visit https://www.stats.govt.nz/integrated-data/. The results are based in part on tax data supplied by Inland Revenue to Stats NZ under the Tax Administration Act 1994 for statistical purposes. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements.

ABSTRACT/RÉSUMÉ

Does Faster Internet Increase Exports? Evidence from New Zealand

This paper explores the relationship between adoption of ultra-fast broadband (UFB) and the export propensity of New Zealand firms. Previous literature have shown that the Internet facilitates exports by reducing search costs and informational frictions in establishing trade relationships. However, the role of faster Internet that enables the use of more recent, advanced, data-intensive digital technologies has not been well explored. This paper shows empirically that adoption of fibre broadband is associated with a higher propensity to enter exporting by New Zealand firms, suggesting that faster Internet has an additional role over traditional Internet in facilitating exporting. The paper also shows that firms that were already using the Internet more intensively prior to adopting fibre experience a stronger increase in export propensity following fibre adoption than those with less intensive Internet use, and that the positive relationship between fibre uptake and exporting is primarily observed among services firms. Instrumental variable analysis to assess the causal relationship between fibre uptake and exporting suggests that the higher export entry among fibre users is driven by self-selection of firms with higher export propensity into fibre uptake.

This Working Paper relates to the 2022 OECD Economic Survey of New Zealand (http://www.oecd.org/economy/new-zealand-economic-snapshot/)

JEL Classification: F14, O33, H54

Keywords: High-speed Internet, Export, Digital capabilities

****

Un Internet plus rapide augmente-t-il les exportations ? Analyse empirique du cas de la Nouvelle-Zélande

Cet article explore la relation entre l'adoption du haut débit ultra-rapide (UFB) et la propension à l'exportation des entreprises néo-zélandaises. La littérature antérieure indique qu'Internet facilite les exportations en réduisant les coûts de recherche et les frictions informationnelles dans l'établissement de relations commerciales. Cependant, le rôle d'un Internet plus rapide qui permet l'utilisation de technologies numériques plus récentes, avancées et gourmandes en données n'a pas été bien exploré. Cet article montre empiriquement que l'adoption du haut débit par fibre est associée à une plus forte propension à entreprendre d'exporter par les entreprises néo-zélandaises, ce qui est cohérent avec le fait qu'un Internet plus rapide joue un rôle supplémentaire par rapport à l'Internet traditionnel dans la réduction des coûts d'exportation. L'article montre aussi que les entreprises qui utilisaient déjà Internet de manière plus intensive avant d'adopter la fibre connaissent une plus forte augmentation de la propension à entreprendre d'exporter après l'adoption de la fibre que celles qui utilisent Internet moins intensivement, et que la relation positive entre l'adoption de la fibre et l'exportation est principalement observée parmi les entreprises fournissant des services. L'analyse par variables instrumentales évaluant la relation causale entre l'adoption de la fibre et l'exportation suggère que la propension plus élevée à entreprendre d'exporter parmi les utilisateurs de fibre est motivée par l'auto-sélection des entreprises ayant une plus forte propension à exporter vers l'adoption de la fibre.

Ce Document de travail a trait à l'Étude économique de l'OCDE de la Nouvelle-Zélande, 2022 (http://www.oecd.org/fr/economie/nouvelle-zelande -en-un-coup-d-oeil/).

JEL Classification : F14, O33, H54

Mots clés : Internet haute vitesse, exportation, capacités numériques

Table of contents

FIGURES

TABLES

Does Faster Internet Increase Exports? Evidence from New Zealand

Lynda Sanderson, Garrick Wright-McNaughton, Naomitsu Yashiro[1]

Introduction

This paper explores the relationship between adoption of ultra-fast broadband (UFB) and the export propensity of New Zealand firms. Internet-based digital technologies, such as websites and online platforms, can increase the visibility of firms to potential foreign customers and reduce the search and informational frictions in establishing trade relationships (Freund and Weinhold, 2004, 2002; Fernandes, et al., 2019). However, digital technologies have evolved dramatically over the past decade, with the emergence of online video conference tools as well as advanced, data-intensive digital technologies such as Cloud Computing, Big Data analysis, and Artificial Intelligence (AI) that require faster and larger data transmission (OECD, 2020). Access to faster Internet is essential for leveraging these new digital tools, which can further promote exports by reducing entry costs and improving firms' productivity. The importance of Internet-mediated trade and communications has also increased through the COVID-19 pandemic as firms across the globe, faced with lockdowns and physical distancing requirements, moved operations online and learnt to operate remotely, largely through the use of Internet-enabled digital tools (OECD, 2021a, 2021b). For a small open economy such as New Zealand, which has long been disadvantaged in trade due to its geographic location, access to faster Internet and greater acceptance of digital communications presents an opportunity to strengthen integration into the world economy and enhance trade opportunities.

This paper exploits rich information on international engagement and ICT use by New Zealand firms collected by Stats NZ through the Business Operations Survey (BOS). The dataset includes information on the export status and adoption of UFB by firms as well as information on their application of digital tools for business activities, which we leverage to infer their capability to exploit faster Internet. The paper finds that exporting firms are more likely to access UFB than non-exporters, even after controlling for their larger size compared to non-exporters and the industries they operate in. To explore the causal relationships between exporting and UFB uptake, the paper makes use of both the longitudinal nature of the data collection and the policy choices made in prioritising the roll-out of UFB to particular areas.

We find that New Zealand firms that adopted UFB in the early years of the national rollout were more likely to start exporting subsequently. This relationship was stronger among firms that were already using the Internet more intensively prior to adopting fibre, a difference which appears to reflect industry differences in ICT use. In particular, we find an economically and statistically significant positive relationship between

[1] Lynda Sanderson is a Principal Advisor of the New Zealand Productivity Commission, Naomitsu Yashiro is an Economist at the Organisation for Economic Cooperation and Development (OECD), Garrick Wright-McNaughton is an Associate Solution Consultant at the FNZ group and a former Research and Data Analyst at the New Zealand Ministry of Business, Innovation and Employment (MBIE). The authors are grateful for the valuable comments and suggestions from David Carey, Richard Fabling, Daniela Glocker, David Maré, Sébastien Miroudot, and Caroline Paunov as well as participants at an internal workshop at the New Zealand Ministry of Business, Innovation and Employment and the International Trade Workshop at Niigata Prefecture University, Japan. Special thanks are due to Sisse Nielsen and Axel Purwin for editorial and statistical assistance.

fibre uptake and export entry among services firms, consistent with their greater use of the Internet to communicate with potential customers and to deliver products via digital channels, but no significant relationship among firms in goods industries, which typically use ICT less intensively. To address the question of whether higher export propensity among UFB adopters reflects a causal relationship from UFB uptake to export entry, we employ an instrumental variable (IV) estimation that exploits the historical patten of UFB roll-out that reflected New Zealand government's policy to prioritise schools and hospitals. The estimation results, while limited by the issue of weak instruments, suggest that the positive correlation between fibre uptake and exporting was driven by self-selection of firms with higher underlying export propensity into early adoption of fibre.

This paper differs from existing studies in two ways: first, it examines the links between export propensity and the shift to high-speed Internet, rather than the use of the Internet itself. It thus belongs to the small literature that highlights the importance of Internet speed on trade and productivity (Abeliansky and Hilbert, 2017; Fabling and Grimes, 2021). Second, this paper explores the role of firms' pre-existing digital capabilities in shaping their use of faster Internet. It observes that while adoption of faster Internet is a consistently positive predictor of export entry, the strength of the relationship depends on how firms are already using the Internet. This finding is in line with the nascent literature that stresses the role of management quality in exports (Bloom et al., 2021).

New Zealand is a particularly interesting case for studying the role of faster Internet in exports. New Zealand suffers from the "tyranny of distance", where its geographic isolation from large markets and suppliers puts it at a disadvantage against other countries. This disadvantage stems from higher shipping costs as well as increased costs in searching for foreign buyers and addressing information asymmetry, which increase with distance (Blum and Goldfarb, 2006). As a result, New Zealand's exports account for only 27% of GDP, considerably below comparable OECD economies, and New Zealand is among the OECD economies least integrated into global value chains (OECD, 2022). Low integration into global trade has weighed on New Zealand's productivity growth by constraining its production scale to the small domestic market and limiting technology diffusion from the global productivity frontier (de Serres, Yashiro and Boulhol, 2014; New Zealand Productivity Commission, 2021). It is therefore particularly important for New Zealand to exploit digital technologies effectively to overcome the disadvantages of geographic isolation.

The next section provides a non-exhaustive review of related literature to set out a conceptual framework for exploring the interaction between faster Internet and the effective use of digital tools in promoting exports. Section 3 describes the data used in the analysis and explores the aggregate links between ICT use and exporting. Section 4 presents the empirical estimation results. Section 5 concludes with policy implications.

Internet and exports

The Internet facilitates exports by helping some firms to start exporting

Since the seminal works by Freund and Weinhold (2002, 2004), the role of the Internet in international trade has been studied extensively. The basic idea underlying these studies is that the Internet reduces search frictions and information asymmetries, which are more prominent in international transactions than domestic (Freund and Weinhold, 2004; Fernandes, et al., 2019). These transaction and search costs generate a sizable fixed cost of export entry, which in turn determines the productivity threshold at which firms can viably compete in export markets (Melitz, 2003). The use of digital tools has the potential to reduce these fixed costs and can thereby allow firms with productivity levels just below this threshold to start exporting (Lawless, 2010). In the case of services trade, the Internet can also increase exports by

drastically reducing the cost of delivering services to foreign customers (Freund and Weinhold, 2002).[2] Faster Internet is likely to reduce the export barriers for firms that are using the Internet more extensively in their communication and marketing activities, and in delivering digital products to their customers.

More intensive use of the Internet is especially likely to increase export entry by small firms, as these firms often struggle to cover the transaction and search costs associated with exports. Small firms are more likely than large firms to export via online platforms to save these conventional fixed costs of export. Sun (2021) showed that widespread use of the Internet increases the share of SMEs in a country's exports, as it reduces the costs of exporting online more than those of traditional exports, thus allowing more small firms to start exporting. In 2019, the probability that an exporting firm with 6 to 19 employees delivers its products and services via the Internet or telephone was about 8 percentage points higher than that of a firm with more than 100 employees, after controlling for the industries firms operated in (Figure 1). [3] Small firms also have ample room to benefit from using the Internet to market their products offshore. They are much less likely to make use of costly and targeted marketing activities such as overseas visits and trade fairs than large firms (Figure 1).

The Internet can also indirectly help firms to start exporting by enabling the use of digital tools that reduce production costs or improve their productivity. For instance, use of the Internet not only reduce the information and search costs to find foreign customers but also suppliers, enabling firms to diversify their suppliers and to source cheaper or better quality inputs from offshore. Digital tools can also help firms improve their processes or restructure their activities. In 2018, 20% of New Zealand firms surveyed in the BOS reported that their use of ICT helped them reduce the input prices paid to suppliers while 50% reported that it played an important role in improving efficiency (Business Operations Survey, 2018). Faster Internet supports the use of more recent digital technologies that facilitate communication, such as video conferencing tools, or boost productivity, such as Cloud Computing, Big Data analysis or Artificial Intelligence, which require the rapid transmission of large amounts of data. Thus, faster Internet can help some non-exporting firms to raise their productivity levels beyond the threshold for export entry.

Earlier studies estimated a gravity equation model augmented with indicators of Internet penetration to test whether countries with better Internet access export more. For instance, Freund and Weinhold (2004) reported that a 10 percentage point increase in the growth of web hosts in a country leads to around a 0.2 percentage point increase in its export growth during the period 1995-99, while Lin (2014) reported a similar impact during 1990-2006. Osnago and Tan (2016) took a step further and examined whether the Internet has a stronger effect on the number of goods exported (extensive margin) or on the average export value per exported good (intensive margin). They find that a 10% increase in a country's share of individuals

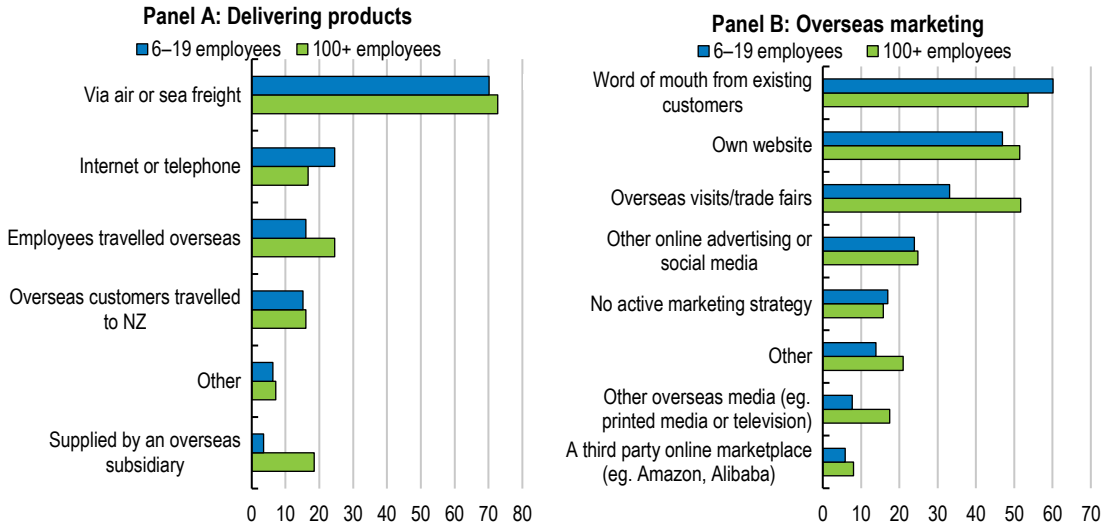
[2] A related issue that is especially relevant for New Zealand, which is geographically distant from large markets and input suppliers, is whether the Internet has been able to reduce the negative impact of distance on trade flows. Empirical evidence suggests otherwise. For instance, the meta-analysis of 1,000 gravity equations performed by Disdier and Head (2008) found that the estimated impact of distance on bilateral trade has increased since the 1970s. Akerman, Leuven and Mogstad (2022) estimated gravity equations on bilateral trade between 420 Norwegian municipalities and 180 countries augmented by municipal-level rates of broadband adoption by trading firms (which they instrument with the share of households having access to broadband). They found that higher adoption of broadband makes bilateral trade more sensitive both to distance and to the economic size of trade partners. Other studies also provide evidence that digital service trade, which is weightless, is nevertheless affected by distance. For instance, Blum and Goldfarb (2006) showed that US imports of digital services consumed over the Internet fall with the distance between the US and the exporting country.

[3] It is possible that small firms are more likely to use Internet for exporting because they are concentrated in industries where it is technically feasible to deliver their products via the internet or telephone, such as Professional and technical services. Indeed, when we do not control for their industry composition, the probability that a small exporting firm delivers its products and services via the Internet or telephone was 13 percentage points higher than that of a large firm.

using the Internet increases the extensive margin of its exports to a given country by an average of 1.5%, and the intensive margin by 0.4%. This suggests that higher Internet adoption allows exporters to find more overseas buyers for their products, thus increasing the range of products exported, rather than increasing sales to existing customers. Along the same lines, Visser (2019) reported that higher Internet use increases the extensive margin of exports from developing to developed countries and alleviates the negative impact of language dissimilarity between trade partners on the extensive margin. Lawless (2010) exploited data from the US Census Bureau to decompose exports by US firms into the number of exporting firms and average exports per exporting firm. She found that a larger number of Internet users in the destination country increases the number of US firms exporting but reduces their average export sales. She interpreted this result as evidence that the Internet reduces the fixed cost of export entry, which increases export entry but decreases export sales per firm as firms with lower productivity levels (thus lower export competitiveness) start exporting.

Conventional measures of Internet use such as the number of Internet subscriptions may not capture communication capacity accurately, since bandwidth speed is highly diverse across subscriptions. Abelinski and Hilbert (2017) reported that average bandwidth data speed per subscription is a more important determinant of exports in non-OECD countries than the number of Internet subscriptions per capita. They interpret this result as reflecting the large variance in Internet speed among developing countries, and evidence of fast Internet promoting exports. Interestingly, in OECD countries, where high-speed Internet is often readily available, the number of subscriptions was a more important determinant of exports than the average Internet speed. Abelinski and Hilbert (2017) interpreted this as the diffusion of faster Internet facilitating exports in developed countries.

Figure 1. Small exporting firms rely more on digital marketing and delivery



Note: Panel A and B summarise the share of exporting firms reporting the use of specific methods for delivering or marketing their products overseas over all exporting firms. Estimated proportions by firm size after controlling for 1-digit ANZSIC industry composition. Reported estimates use Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees. The survey question text is provided in Annex A.
Source: Authors' calculations based on Stats NZ's Business Operations Survey, International Engagement Module, 2019.

More recent studies have exploited firm-level data to directly identify the effects of the Internet on a firm's export entry. For instance, Ricci and Trionfetti (2012) used the World Bank's Enterprise Survey and found that, among their sample of firms in developing countries, the use of e-mail and websites is associated with a 14% or 7% higher probability, respectively, of being an exporter. Hagsten and Kotnik (2017) used

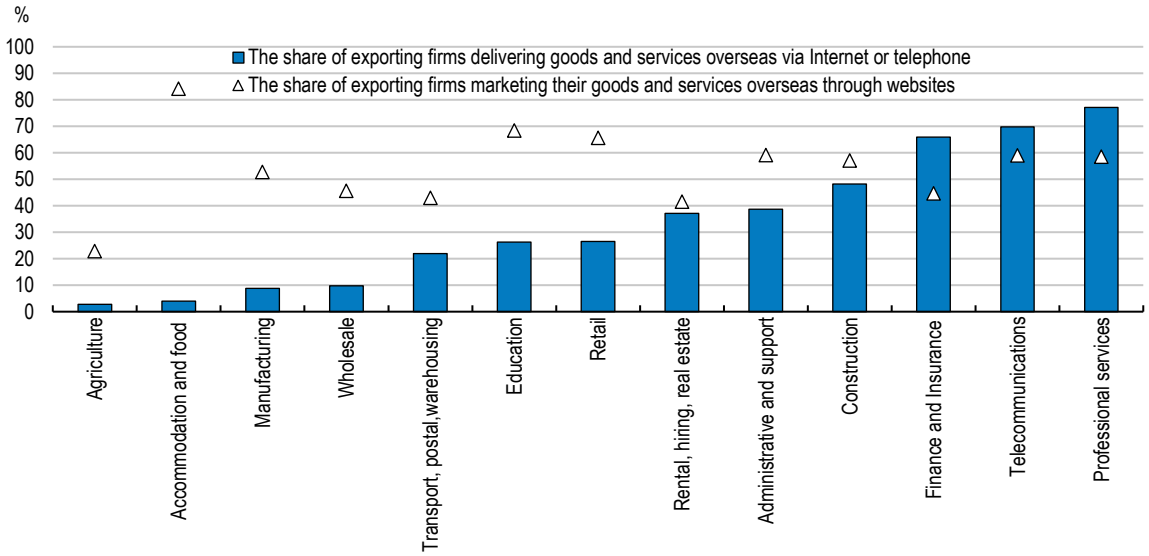
sample data of SMEs in several European countries and regressed the probability of export entry and export sales on the use of digital tools. They found that owning a website increases the probability of export entry a year later. In contrast, selling products online boosts export sales a year later among incumbent exporters but does not increase the probability of export entry. Moreover, for several countries, a higher share of employees using broadband Internet also increases future export entry. However, their empirical specifications are prone to endogeneity between the adoption of digital tools and export entry, since they do not fully control for unobserved factors that can drive both the take-up of digital tools and export entry, such as the managerial capabilities. Also, their specifications with a relatively short time lag (one year) between the adoption of ICT tools and export entry can be prone to reverse causality, where firms seeking to start exporting or boosting export sales adopt digital tools to serve their larger client base.

Empirical evidence from studies seeking to identify the causal impact of the Internet on export entry is mixed and nuanced. Kneller and Timmis (2016) explored the impact of adopting broadband on export entry by service-sector firms in the United Kingdom. They addressed the potential endogeneity by instrumenting broadband adoption by these firms with spatial differences in broadband availability, an approach commonly used in literature assessing the impact of broadband on firms' performance, finding that broadband adoption had a significant positive effect on export entry only for firms in the business services sector. Fernandes et al. (2019) applied a difference-in-difference approach pioneered by Rajan and Zingales (1998) to the microdata of Chinese manufacturing firms and data on China's province-level Internet usage (the number of internet users per 10,000 people). They find that higher Internet usage in a province is positively correlated with the probability of a firm being an exporter and with the export value of incumbent exporters in industries that rely more on the Internet. Fernandes et al. (2019) see this as evidence that the rapid Internet rollout in China after the late 1990s boosted exports.

Overall, existing studies suggest that the export-promotion effects of the Internet depend on both sector and firm level characteristics, as well as on the quality of Internet infrastructure in both the exporting and destination markets. For instance, the extent to which products can be exported via the Internet is determined by the characteristics of the products concerned, with services that involve either physical proximity or intensive communication and customisation less amenable to digital sales and delivery. Indeed, the share of New Zealand firms using the Internet or telephone as means of delivering goods and services to customers overseas differs substantially across industries (Figure 2). In particular, this mode of delivery is common in Telecommunications, Financial Services, and Professional Services. However, industries with limited use of the Internet for product delivery still use the Internet intensively to market their goods and services to foreign customers (Figure 2).

Figure 2. The use of the Internet for export sales differs across industries

The share of exporting firms using the Internet to deliver or market their goods and services overseas, 2019



Note: The figure summarises the share of exporting firms using the indicated method in delivering or marketing their products overseas over all exporting firms. Mining, Electricity, Gas, Water and Waste, Healthcare and social services, Art and recreational services, and Other services are not shown due to very low numbers of exporting firms. Reported proportions use Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees.
Source: Business Operations Survey, International Engagement Module, 2019.

Fast Internet helps firms that can make strategic uses of digital tools

The benefits of new technologies hinge on how effectively they are deployed. Firms' capabilities to exploit new technologies such as digital tools are underpinned by complementary investment in intangible capital (Brynjolfsson, Rock and Syverson, 2021; Corrado, et al., 2021). An example of such intangible capital is organisational changes that include new processes and structures, knowledge sharing, redesigned monitoring, reporting, and incentive systems (Brynjolfsson, Hitt and Yang, 2002; Garicano, 2010; Cardona, Kretschmer and Strobel, 2013). Investment in intangible capital is often risky, and typically costs more than the direct financial costs of adopting faster Internet or digital tools (Brynjolfsson, Rock and Syverson, 2021). However, a successful combination of digital technologies and organisational capital acts as a source of competitive advantage, which competitors may find difficult to replicate. Although it is difficult to capture the impact of strategic deployment of digital technologies on corporate performance, some of their aspects have been documented. For instance, Bloom et al. (2012) reported that US multinational enterprises operating in Europe use digital technologies more intensively than European firms and reap larger productivity gains from ICT capital. They found that the higher productivity of ICT capital is mostly explained by superior human resource management by the US multinationals, suggesting that better people management practices boost the benefits of digital technologies. Black and Lynch (2001) estimated the contribution of various workplace practices to US firms' productivity and found that a higher share of non-managerial workers using computers is associated with higher plant-level productivity, while a higher share of managers using a computer is not. Their finding that computer usage by mid- to low-level workers improves firm performance is in line with findings by Bloom et al. (2014) that lower costs in gathering information enabled by digital tools increase the value of more decentralised decision-making. These studies indicate that the impact of fast Internet like UFB hinges on good management strategies that make the most of it to enhance efficiency or capture more sales. For instance, Fabling and Grimes (2021) reported that adopting UFB improved the productivity of New Zealand firms mainly for those that also

implemented complementary measures, such as introducing new work practices or changing staffing levels or the skills mix of employees.

Strong managerial capabilities are essential for exporting, since firms that seek to export must build up not only larger production capacity but also successful globalisation strategies (Gkypali, Love and Roper, 2021). For instance, Bloom et al. (2021) observed for a large sample of US and Chinese firms that those with better management practices are more likely to export, and conditional on exporting, they sell more products to more destinations and earn higher export revenues and profits. They also reported that better-managed firms sell higher-quality products and charge higher export prices, while making use of higher-quality imported inputs and sourcing inputs from more a diversified set of countries. Bloom et al. (2020) found that improved management practices, especially product quality control, led to a significantly higher chance of export entry, based on a randomized control trial that offered management consulting to Indian firms. Good global marketing and production strategies, in turn, enhance export entry.[4] While the capabilities of New Zealand firms to exploit UFB cannot be captured directly, this paper infers them from their usage of the internet and the functionality of their digital tools. By capturing the intensity with which firms were using the Internet and digital tools before adopting UFB, the paper examines whether firms that use ICT more intensively are more likely to benefit from UFB adoption.

Ultra-Fast Broadband rollout in New Zealand

New Zealand started its nationwide rollout of fibre broadband in 2010 under its Ultra-Fast Broadband (UFB) Initiative. While the use of broadband by New Zealand firms was already widespread by 2010, the composition of broadband connection types changed drastically over the following decade (Figure 3). The share of firms with fibre-to-the-premise connections rose from 9% in 2010 to 52% in 2018 and reached 64% in 2020. At the same time, the share of firms with digital subscriber line (DSL) connections decreased from 74% to 35%. The government aims to provide fibre connections to 87% of the population in over 412 towns and cities by the end of 2022. According to the Crown Infrastructure Partners (2022), 86% of New Zealanders could access fibre, while 70% had taken it up so far. The share of fibre in fixed broadband connections in New Zealand is higher than in many other OECD countries (Figure 4).

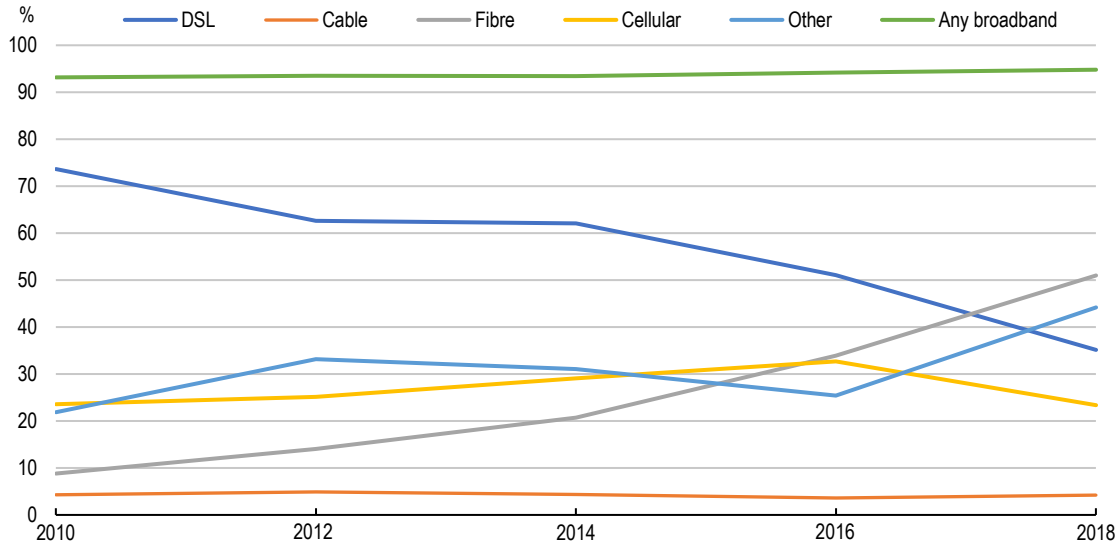
Despite the progress in the nationwide roll-out, local unavailability has remained a key factor preventing New Zealand firms from taking up UFB. While just over 50% of firms had fibre connections by 2018, only half of the remaining firms were planning to adopt UFB. Among those without a plan to adopt UFB, close to 60% cited the unavailability of UFB in their locations as the reason, a share that is somewhat higher than back in 2012 (Table 1).

One notable feature of the UFB rollout in New Zealand is that it has prioritised schools. While only 10% of primary schools had fibre connections in 2012, almost all state schools had them by 2016. This provided a basis for expanding UFB access to nearby households and businesses. In their exercise to identify the effect of adopting UFB on subsequent changes in productivity of New Zealand firms, Fabling and Grimes (2021) exploited this fact by instrumenting the UFB adoption by firms by their geographic proximity to a primary or secondary school.

[4] Caliendo et al. (2018) showed that export entry is associated with an organisational change that adds layers of hierarchy. This is because the larger production quantity as the result of exporting makes it less costly for firms to add a layer of managers who solve non-routine problems, rather than investing in boosting the knowledge of existing employees and managers so that they can solve an increased number of more diverse problems (Caliendo and Rossi-Hansberg, 2012). While Caliendo et al. (2018) considered such organisational change as a firm's response to export entry, firms may also engage in such organisational changes as a part of capacity building for export entry. Investment to boost production capacity or productivity motivated by export entry can precede or follow the actual entry, due to forward-looking decision-making by firms (Lileeva and Trefler, 2010; Fabling and Sanderson, 2013).

Figure 3. The uptake of fibre among New Zealand firms increased steadily

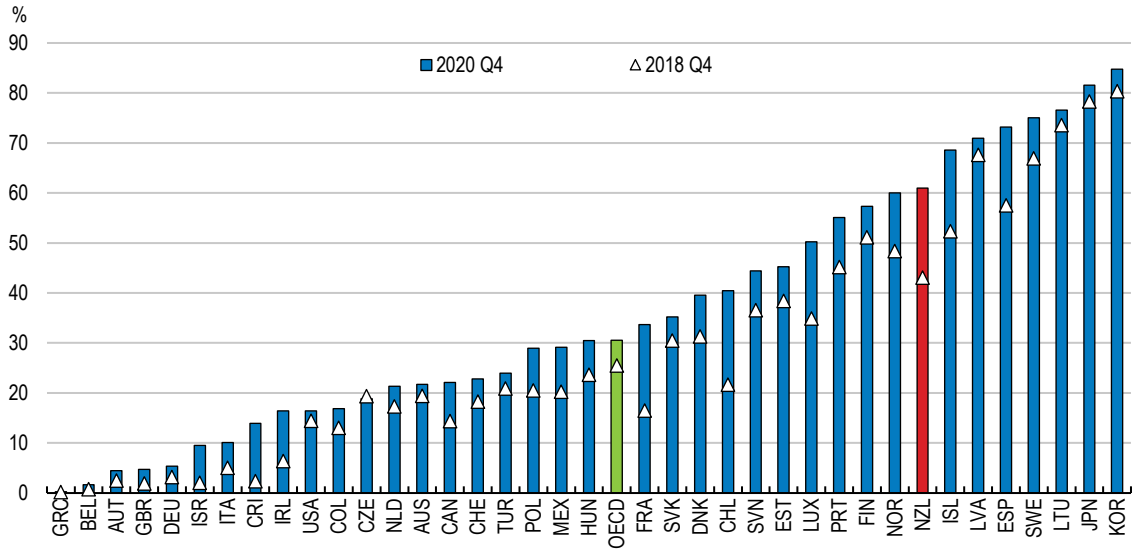
Share of firms reporting each type of broadband internet connection, 2010-2018



Note: Firms may report more than one type of connection. Reported proportions are based on Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees.
Source: Authors' calculations based on Stats NZ's Business Operations Survey, 2010-2018.

Figure 4. The share of fibre connections in New Zealand is relatively high

The share of fibre connections in total fixed broadband



Source: OECD, Broadband Portal, http://www.oecd.org/sti/broadband/broadband-statistics/

Table 1. Unavailability is a key reason for firms not adopting UFB

Shares of firms with different fibre adoption statuses and reasons for having no plan to adopt fibre, 2012 and 2018

	2012	2018
A. Fibre status		
Has fibre	15.5%	51.8%
Plans to get fibre	27.9%	23.0%
No plans to get fibre	56.6%	25.2%
B. The reason for having no plans to get fibre		
Not available in local area	47.1%	59.1%
Start-up costs are too high	8.5%	10.3%
Ongoing connection and usage costs are too high	5.4%	6.1%
Needs met by other technologies	20.4%	18.1%
Not compatible with existing technologies	1.2%	2.8%
None of the above	29.0%	16.2%

Notes: Reported proportions are based on Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees.
Source: Authors' calculations based on Stats NZ's Business Operations Survey, 2012 and 2018.

Data and statistical observation

Data

This paper exploits linked survey and administrative data from Stats NZ's Longitudinal Business Database (LBD) and Integrated Data Infrastructure (IDI). The LBD contains information on the full population of firms operating in New Zealand since April 1999, linking wide-ranging firm-level information from both administrative and survey data sources. The IDI holds a diverse range of datasets at the individual and household level and is directly linked to the LBD through individual and corporate income tax records.[5]

The use of these linked data brings together a range of firm characteristics known to predict firms' export propensity, such as firm size (represented by the number of employees and working proprietors), capital intensity, human capital, industry, and indicators of R&D and foreign investment. Furthermore, the data include information on UFB uptake and on how firms were using the Internet before adopting UFB, as well as detailed information on firm location, which is used to construct an instrument for UFB adoption.

The primary dataset of interest for this paper is the Business Operations Survey (BOS) – an annual, modular survey of businesses administered by Stats NZ. The survey population is defined as all private-for-profit firms with rolling mean employment of at least six (roughly 35,000 to 40,000 firms). From this population, between 5,500 and 7,500 useable responses are collected each year, based on a random sample of the population, stratified by industry and firm size. The BOS's modular nature allows the collection of information on a wide range of topics, including business and management practices, R&D, and innovation. Three aspects of the BOS are of particular interest for this paper:[6]

[5] See Fabling and Sanderson (2016) for further detail on the structure and coverage of the LBD, the Stats NZ website (https://www.stats.govt.nz/integrated-data/integrated-data-infrastructure/) for information on the IDI, and Fabling and Maré (2015) for an in-depth discussion of employment measures.

[6] A copy of the relevant questions is provided in Annex A.

- Basic information on firms' international engagement is collected annually, in Module A of the survey. Specific items used in the current paper include export intensity (exports as a proportion of total sales) and indicators of whether the firm has inward and outward foreign direct investment.[7]
- Information on firms' use of ICT is collected in a topic-specific module, collected biennially in even-numbered years. Responses to this module provide information on connection type – whether or not the firms are connected to broadband, and more specifically to UFB (fibre-to-the-premise); their uptake of a range of ICT tools and practices, including whether the firm has a web presence, and whether they use the internet to share information internally or with other organisations; and their perceived outcomes from ICT use, such as better sales or marketing methods or better coordination of staff and business activities.[8]
- To complement the annual data on international engagement above, more detailed information on firms' overseas sales of goods and services from the International Engagement Module run (in varying forms) on a four-year cycle is used. The paper exploits the most recent wave (2019), which includes specific questions on the use of digital media to market goods and services overseas, and the mode of delivery to overseas customers.

With a comprehensive sampling frame supported by administrative and survey data, and response rates consistently above 80%[9] the BOS provides a representative picture of the internationalisation and ICT use of New Zealand firms, including the large population of small and medium-sized enterprises (with 6-20 employees). Nevertheless, there are some caveats to the use of BOS data. First, the BOS surveys the use of UFB only from 2010 when the UFB initiative was implemented. Consequently, the empirical analysis in this paper is limited to the period from 2010 onwards. Second, the 2012 BOS included a modification to the text of the survey question used in this paper to identify exporters. Before 2012, firms were asked to report the share of export sales over total sales in a 3-digit free-text box. Following the observation that some firms were reporting a decimal, rather than an integer, an additional note was added in 2012 directing firms to round the export sales share to the nearest percentage. It specifically directed firms to round up any share between 0 and 1% to 1%. This additional instruction appears to have led to a substantial rise in the measured number of exporters in 2012, suggesting that firms with small or occasional export shipments were now identifying as exporters where they would not have under the old instructions. To maintain consistency over time and to focus the analysis on firms with a meaningful level of export activity, we classify only the firms reporting exports that exceed 1% of total sales as exporters.

Finally, we make use of location-based data that help capture the availability of UFB to individual firms. These data are based on the location of primary and secondary schools, sourced from the Longitudinal Business Frame within the LBD, and historical information on the timing of the UFB rollout by region, provided by Crown Infrastructure Partners, the agency responsible for managing the Government's investment in UFB and rolling out rural broadband and mobile coverage under the Rural Broadband Initiative and Mobile Black Spots Fund. The information on the location of schools is used to compute the physical linear distance between each firm and the nearest school. This is motivated by the fact that the government prioritised connecting schools and hospitals to the fibre network, enabling firms located nearby to also have fibre connected to their premises (see section 2). The historical information on the UFB rollout indicates the year when the rollout began and the year it was completed for each region. A degree of judgement is required in terms of where the boundaries of these regions should be drawn. Combining the school distance with the historical data on regional coverage gives a plausible proxy for the availability of

[7] Module A also includes a question on new market entry. Sample size issues prevented analysis of market entry and export intensity among existing exporters.

[8] The BOS ICT module was developed in the mid-2000s, and thus does not survey the use of more recent or specialised digital technologies, such as the Internet of Things, AI, or industry-specific technologies such as smart monitoring systems. An updated ICT module will be introduced in the 2022 survey round.

[9] Responses to official Stats NZ surveys are mandatory under the Statistics Act 1975.

UFB at the firm level. We use this proxy to instrument the adoption of UFB in our empirical analysis discussed in section 4 below.

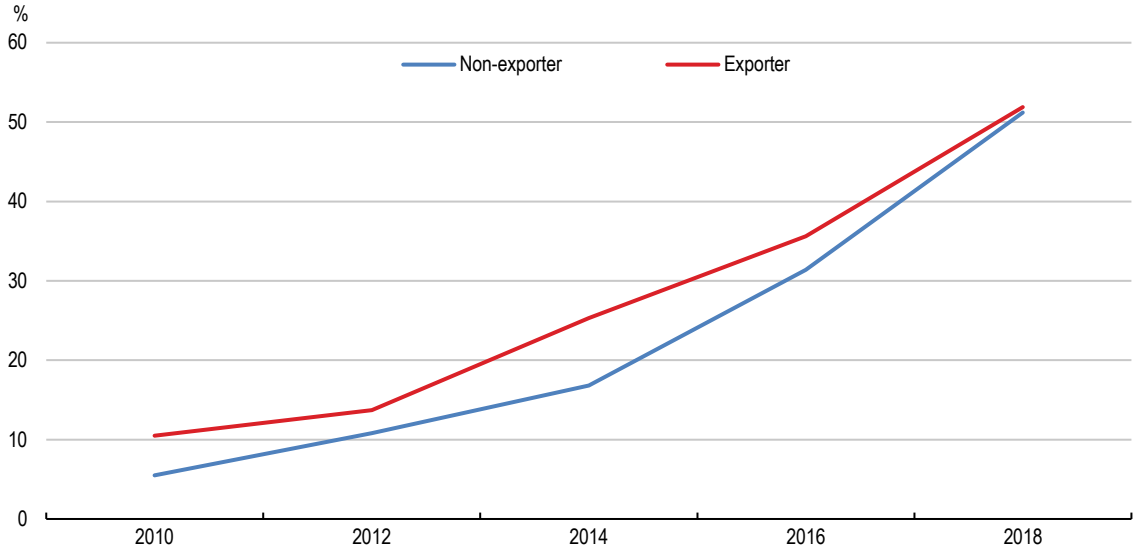
The use of the Internet and digital tools in exports: first look

Based on the linked data described above, this section describes how the use of the Internet and digital tools differs between New Zealand's exporting and non-exporting firms. In 2010, when the government initiated the nationwide UFB rollout, exporting firms were more than twice as likely as non-exporting firms to report having a UFB connection, with 16.7% of exporters and 7.6% of non-exporters reporting they had a fibre broadband connection. The predicted shares of fibre broadband connections over time for exports and non-exporters, after controlling for their sizes and the industries they operate in, indicate that the gap between exporters and non-exporters in UFB adoption narrowed throughout the 2010s as the UFB rollout progressed and fibre-to-premise became more readily available (Figure 5).

Overall, some 95% of New Zealand firms had access to some type of broadband by 2018 (Table 2, Panel A). Nevertheless, not all firms were using the Internet or digital tools to the same extent or purposes. For instance, while 92% of the BOS respondent firms used the Internet for finance and banking in 2018 and 85% used it to purchase goods and services, some 57% used the Internet for enhancing internal communication while 45% used it to enhance collaboration with business partners (Panel B). Similarly, while 73% of BOS respondent firms had a web presence (i.e., they had websites, home pages or other online presence), relatively few were making use of their websites for functions other than providing information. For instance, while 89% of firms with a web presence used it to provide information on their product prices, less than a third used it to take orders, receive online payment, or provide after-sales support (Panel C).

Figure 5. UFB take-up has risen among both exporting and non-exporting firms

Share of firms with fibre broadband connection, %



Notes: Reported proportions are based on Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees. Exporting is defined as reporting greater than 1% of sales from exports. Estimated proportions by export status after jointly controlling for one-digit industry and size group.
Source: Authors' computation based on Stats NZ Business Operation Survey.

Table 2. Uptake of digital tools, 2008 and 2018

Share of firms reporting each type of usage

	2008	2018
A. Connection types		
Uses internet	93%	97%
Broadband connection	89%	95%
Fibre connection	9%*	51%
B. Uses of the internet		
Finance (online banking, payments etc.)	85%	92%
Recruitment	36%	61%
Staff training	20%	48%
Within-firm information sharing	38%	57%
Inter-firm information sharing	33%	45%
Purchasing inputs	63%	85%
Selling products	40%	56%
Has own website	57%	73%
C. Functions included on the website (conditional on having a website)		
Providing information on products and prices	92%	89%
Customised page or information to repeat customers	32%	34%
Taking orders for the firm's products	25%	29%
Receiving online payment	12%	20%
Providing after sales support online	25%	31%
Collecting customer information	21%	25%
Offering privacy or security information	19%	27%

Source: Authors' calculations based on Business Operations Survey 2008 and 2018

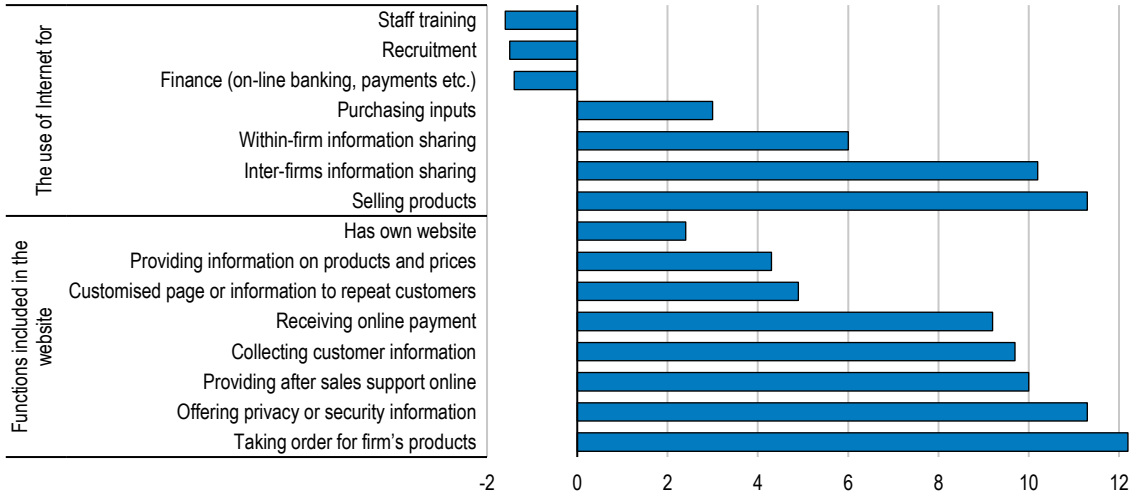
Notes: Reported proportions are based on Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees. *Fibre uptake reported for 2010 as the question was not asked in 2008.

While access to UFB became ubiquitous, capabilities to make the best use of faster Internet continue to differ significantly between exporting and non-exporting firms. Indeed, New Zealand firms that export use digital tools more intensively and strategically than non-exporting firms. For instance, exporters are more likely to use the Internet for communication and collaboration purposes and to own websites with more functions. Figure 6 describes the extent to which exporting firms are more likely than non-exporters to put the Internet to specific uses or to have their websites equipped with specific functions, controlling for differences in firm size and industry composition. For example, the probability that an exporting firm uses the Internet to share information with business partners or sells products online is more than 10 percentage points higher than for non-exporters. Exporters are also significantly more likely to own websites equipped with more functions, such as an online order facility or after-sales support.

Exporters are also more likely than non-exporters to engage in complementary activities to maximise the impact of their ICT investment (Figure 7). They are more likely to upgrade employees' skills, invest in research and development (R&D), or introduce new work practices. All these activities can be interpreted as investment in intangible capital, which has been observed to complement digital technologies in boosting productivity (Corrado et al., 2021). Exporters also report a wider range of benefits from their ICT use (Figure 8). Many of these benefits strengthen firms' capacity to export. For instance, greater understanding of markets would reduce the information costs associated with export entry, while better sales and marketing methods would improve the firm's visibility to foreign customers. Other benefits like improved quality management or introduction of new goods or services can boost productivity.

Figure 6. Exporters make greater use of the Internet and digital tools

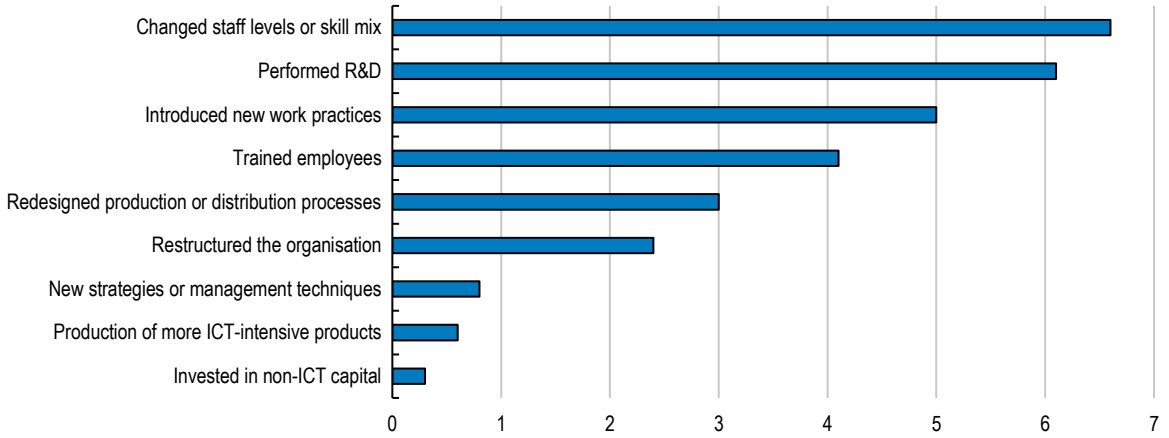
Exporters' advantage over non-exporters in specific Internet uses or website features, percentage points, 2018



Note: The chart displays how much more likely exporters are than non-exporters to use the Internet for a given purpose or to have a specific function on their websites. Reported proportions are based on Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees. Exporting is defined as reporting greater than 1% of sales from exports. Estimated proportions by export status after jointly controlling for one-digit industry and size group.
Source: Authors' calculations based on Business Operations Survey 2018.

Figure 7. Exporters are more likely to undertake activities that complement ICT

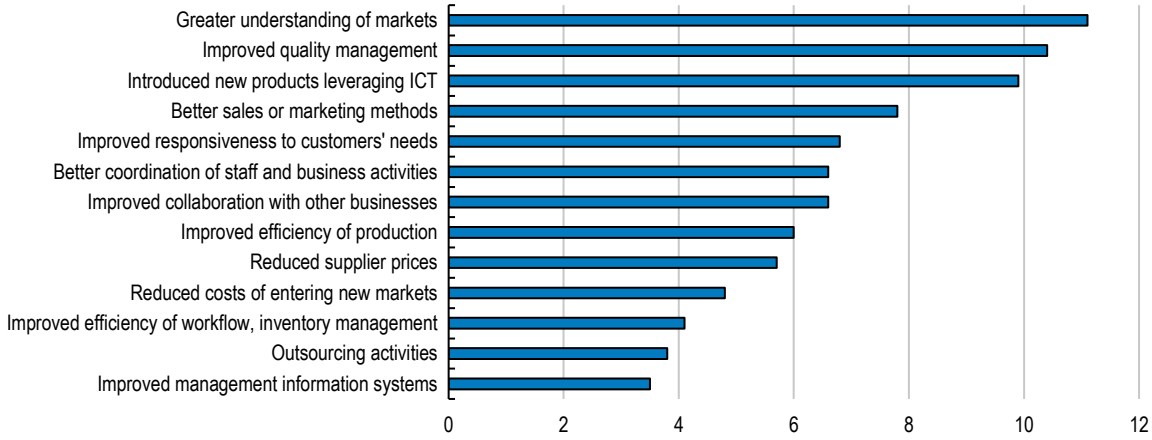
Exporters' advantage over non-exporters in activities to increase the benefits from ICT, percentage points, 2018



Note: The chart displays how much more likely exporters are than non-exporters to undertake specific activities to increase the benefits from ICT, after controlling for differences in firms' size and industry. Reported proportions are based on Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees. Exporting is defined as reporting greater than one percent of sales from exports. Estimated proportions by export status after jointly controlling for one-digit industry and size group.
Source: Authors' calculations from the Business Operations Survey 2018

Figure 8. Exporters are more likely to report benefits from their ICT use

Exporters' advantage over non-exporters in realising benefits from ICT, percentage points, 2018



Note: The chart displays how much more likely exporters are than non-exporters to realise the listed benefits from ICT, after controlling for differences in firms' size and industry. Reported proportions are based on Stats NZ's imputation and sampling weights to represent the population of firms with 6 or more employees. Exporting is defined as reporting greater than 1% of sales from exports. Estimated proportions by export status after jointly controlling for one-digit industry and size group.
Source: Authors' calculations from the Business Operations Survey 2018.

Empirical estimation

This section explores empirically the link between UFB adoption and exporting. Several factors can drive the apparent difference between exporters and non-exporters in their adoption of UFB and the use of digital tools, even after controlling for firm size and industry. For instance, the positive correlation between UFB adoption and exporting can be the result of hysteresis in exports and UFB connection status. The large fixed costs firms incur to enter export markets create inertia in export participation: since these fixed costs are non-recoverable, firms that exported last year are very likely to export this year as well even if they run small losses. At the same time, firms that adopted UFB are unlikely to downgrade to a slower connection. By focusing on export entry rather than export status and adoption of UFB instead of UFB connection status, this paper reduces the potential bias caused by these related forms of hysteresis.[10]

To infer how UFB adoption predicts export entry, this section focuses on export entry by New Zealand firms in the early years of the UFB rollout and tests whether firms that adopted UFB were subsequently more likely to start exporting. This "event study" type analysis provides a rather straightforward timeline from UFB adoption to exporting. Nevertheless, the adoption of UFB itself may not have been random: firms that foresaw great benefits from the use of faster Internet, such as its effects in facilitating export entry or improving productivity, could have self-selected into adopting UFB. As such, the relationship between UFB adoption and export entry from our event study model cannot be interpreted as causal. Also, if firms that benefit most from faster Internet indeed chose to adopt UFB at the early years of its rollout, the same relationship between UFB adoption and export entry may not apply for firms that adopted UFB in later years. This is because the firms that adopted UFB in early years of rollout are qualitatively different from those that adopted in later years. To address these issues, we seek to identify the impact of a random adoption of UFB by exploiting the geographic variation in the timing of the fibre rollout across New Zealand (described in section 3) as an instrument for each firm's UFB adoption.

[10] We also conducted exploratory analysis on the relationships between UFB adoption and firms' export intensity (the share of sales coming from exports), entry into new export markets, and exit from exporting. These analyses are not included in the paper due to the small number of incumbent exporters with the required longitudinal BOS information.

Estimation model for the event study

This sub-section estimates a predictive model of whether a firm will enter exporting conditional on adopting UFB, controlling for prior usage of ICT and firm characteristics. It restricts the analysis to the population of firms that neither exported nor had a UFB connection in the previous wave of BOS (conducted two years earlier since the BOS ICT module is biennial). It then observes whether firms that adopted UFB between the previous wave of BOS (at year *t-2*) and the current wave (year *t*) have a higher probability of exporting, conditional on their observed characteristics and ICT use at *t-2*. As discussed above, the impact of UFB adoption may take time to materialise if, for example, firms need to invest in complementary intangible assets. Therefore, we separately estimate the probability of exporting in the period immediately following UFB adoption (in year *t*) and in the next period (at year *t+2*). That is, we estimate the following two equations:

$$P(X_{it}=1) = a + \beta_1\, adopts\ UFB_{it} + \beta_2\, ICT\ intensity_{i.t-2} + \beta_3\, ICT\ process\ focus_{i.t-2} + \beta_4\, adopts\ UFB_{it} \times ICT\ intensity_{i.t-2} + \beta_5\, adopts\ UFB_{it} \times ICT\ process\ focus_{i.t-2} + yZi_{t-2} + \phi_t + \varepsilon_{it} \quad (1)$$

and

$$P(X_{it+2}=1) = a + \beta_1\, adopts\ UFB_{it} + \beta_2\, ICT\ intensity_{i.t-2} + \beta_3\, ICT\ process\ focus_{i.t-2} + \beta_4\, adopts\ UFB_{it} \times ICT\ intensity_{i.t-2} + \beta_5\, adopts\ UFB_{it} \times ICT\ process\ focus_{i.t-2} + yZ_{it-2} + \phi_t + \varepsilon_{it+2} \quad (2)$$

t = 2012, 2014

$\varepsilon_{it} \sim i.i.d.$

The key explanatory variables are: *adopts UFB*, an indicator variable taking the value one if the firm reports having a fibre-to-the-premise connection in the current survey (at year *t*) but reported not having it in the previous survey (at year *t-2*), and two variables capturing the firm's capabilities in exploiting digital tools at *t-2*, *ICT intensity* and *ICT process focus.* These variables are principal components of the rich information on the ICT use, as described in detail below. The model also includes interactions between UFB adoption and these principal components. Positive coefficients on the interaction terms indicate the role of existing capabilities in enhancing the effects of UFB in enhancing export entry. The term Z_{t-2} is a vector of firm characteristics which have been shown in the literature to predict export entry. These are: firm size, captured by the natural log of the number of employees; labour productivity; average labour quality[11]; indicators of R&D and inward and outward foreign investment; 1-digit ANZSIC06 industry dummies; and the natural logarithm of employment density in the area the firm is located in, measured as employed persons per square kilometre. It is intended as a proxy for regional characteristics that can promote export entry and also controls for the possibility that the UFB roll out prioritised regions with greater economic activity.[12] The model also includes a set of year dummies denoted as ϕ_t. Annex B provides detailed information on the sources and definitions of these variables, as well as summary statistics for the samples

[11] Firm level measures of average labour quality were developed by Maré, Hyslop and Fabling (2016), based on the worker-firm fixed effect model of Abowd, Creecy and Kramarz (2002). These provide an alternative to the use of qualifications or occupation data (neither of which is comprehensively captured in the IDI) and are intended to capture complex differences in skill sets across individuals which can be observed by their employers but cannot be seen in the data. We aggregate the individual level measure of labour quality to a firm level by combining the average worker fixed effects (that capture unobservable skills) and the average estimated age-gender wage premia (which capture the experience effects) across all individuals working for the firm.

[12] If a firm operates in more than one location, we take the maximum of the employment densities of the area units the firm operates in.

used in core estimations. For simplicity, the model is estimated as a linear probability model (OLS), a standard approach employed since Bernard and Jensen (1999).[13]

The share of exporting firms differs considerably across industries, partly because the nature of some services makes them difficult to export. For this empirical analysis, we restrict our sample to firms operating in industries where exporting is expected to be technically feasible in most cases. The six 1-digit ANZSIC06 industries where at least 10% of firms report export sales in most years are: Agriculture, Forestry and Fishing; Manufacturing; Wholesale Trade; Information Media and Telecommunications; Professional and Technical Services; and Administrative and Support Services. While the share of exporting firms is also high in the Transport, Postal and Warehousing industry, we exclude firms in this sector as well because we cannot exclude the possibility that some respondents are reporting the international transportation of goods on behalf of their customers as their own export activity.

To conduct the longitudinal analysis of export entry, we restrict the sample to firms that self-reported as non-exporters and had no UFB connection in the initial period (*t-2*). Furthermore, we drop firms for which we do not have the requisite information – that is, BOS responses with complete answers to the questions on exporting and broadband connection at time *t* and *t+2*, and a complete set of information on firm characteristics in the initial period (*t-2*). At the same time, we boost the sample size for the estimation by including the BOS top-up sample. This is the sample of between 140 and 1650 firms per year that are not included when Stats NZ computes the aggregate statistics but were sampled to fulfil a specific purpose (such as oversampling minority groups or creating an overlapping sample to facilitate the transition from the ANZSIC96 to ANZSIC06 industry classification) or to increase the longitudinal coverage of the survey. Overall, firms in the estimation sample tend to be larger than the average of the overall population, as larger firms are more likely to be tracked across multiple waves of the BOS.

Principal component analysis

The extent to which firms can benefit from UFB is expected to differ according to their capabilities in leveraging digital tools (section 2). Faster Internet speed is unlikely to increase the probability of export entry by firms using the Internet for generic purposes such as e-mail and banking. In contrast, it can boost export propensity if firms use the Internet more intensively to deepen inter-firm collaboration, for instance through joint innovation or better communications with their customers, or to improve their productivity by enhancing the efficiency of internal processes. To assess the role of existing capabilities in shaping the impacts of UFB, we construct measures that capture aspects of these capabilities based on the rich information on ICT use by New Zealand firms.

We apply principal component analysis (PCA) to firms' responses to the questions in the BOS ICT module. PCA reduces the dimensionality of large datasets while retaining as much information as possible. In particular, it summarises a large number of variables into a smaller number of linear functions of these variables (principal components) by maximising their variance (information) while ensuring that they are not correlated with each other (Jolliffe and Cadima, 2016). The principal components are constructed from the answers to BOS questions related to the activities for which firms use the internet and the features and facilities available on their websites, which are documented in Figure 6. To differentiate between activities that the firm undertakes and the (perceived) result of those activities, we do not use the information on reported benefits from the use of the ICT (Figure 8).[14] We estimate principal components using biennial ICT modules for the period 2010-2018. Table 3 presents the loadings on each of our ICT variables across

[13] An alternative version of the model using a probit specification yielded qualitatively similar results.

[14] We also compared firms that undertook more or fewer complementary activities to benefit from their ICT (observed in Figure 7). However, these activities had neither a direct relationship with export entry nor a mediating relationship through their interactions with UFB adoption.

the first two principal components. These components collectively capture almost 40% of the variation in the data. We use these two components in the estimation model described above.[15]

Table 3. Principal component loadings, first 2 components

	Comp1 (Intensity)	Comp2 (Process)
Uses of the internet		
Finance (online banking, payments etc.)	0.083	0.139
Recruitment	0.239	0.326
Staff training	0.254	0.366
Within-firm information sharing	0.263	0.346
Inter-firm information sharing	0.232	0.306
Purchasing inputs	0.214	0.229
Has own website	0.346	0.069
Functions included on the website		
Providing information on products and prices	0.304	0.063
Customised page or information to repeat customers	0.301	-0.207
Taking orders for the firm's products	0.294	-0.404
Receiving online payment	0.266	-0.412
Providing after sales support online	0.304	-0.187
Collecting customer information	0.235	-0.179
Offering privacy or security information	0.309	-0.152
Eigenvalues	3.914	1.648
Share of data variance explained (%)	28.0	11.8
Cumulative share of data variance explained (%)	28.0	39.7

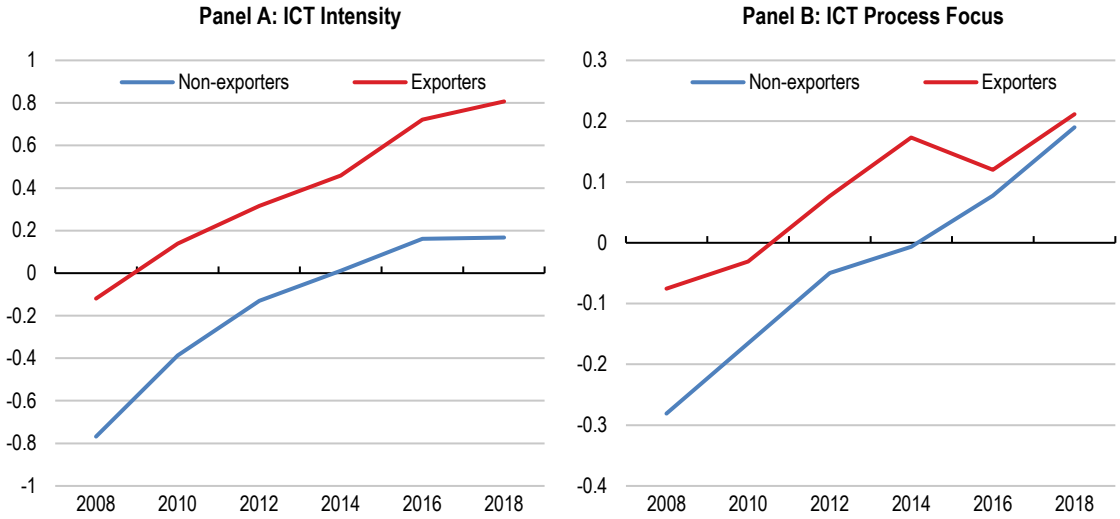
Notes: Eigenvectors and eigenvalues for the first two Principal Components. Principal components are estimated over the full sample of firms with available information, 2008-2018.
Source: Authors' calculations

The first component, which we denote as "ICT intensity," has positive and relatively consistent loadings across all the response categories, thus giving a broad indication of the extent to which firms use the Internet across the activities depicted in Figure 8. Over the sample period, ICT intensity increases rapidly for both exporters and non-exporters but is consistently higher for exporters (Figure 9, Panel A). The second component, denoted as "ICT process focus", has strong positive loadings on uses of the Internet, but negative loadings on more sophisticated website functions. We interpret this component as indicating the extent to which firms are using the Internet for enhancing the efficiency of internal processes, such as operations and human resources (training, recruitment, communications etc.), for a given level of overall ICT intensity. This component has also risen over the sample period and while it is higher for exporters than non-exporters the gap between exporters and non-exporters narrowed toward the end of the sample period (Panel B).

[15] While the principal components are estimated using the full sample of firms over the period from 2008 to 2018, the estimations use a smaller sample of firms with the conditions described above. The estimated principal components in these restricted samples do not have the mean value of zero and are not orthogonal to each other. Annex B provides the means and standard deviations of each component for all the subsamples.

Figure 9. Exporters use the Internet and digital tools more intensively

Mean values of principal components, by export status



Notes: Principal components are estimated on the full sample of firms, using data from ICT modules 2008-2018. Reported averages do not include industry or firm size controls.
Source: Authors' computation based on data from the Business Operations Survey.

Estimation results

Table 4 presents the estimation results starting from the parsimonious models with only UFB adoption as the key explanatory variable to the core models with principal components and their interactions with the UFB adoption. Columns 1 and 2 reflect the statistical observation above: adopting UFB is associated with a higher likelihood of export entry, both contemporaneously and within the following two-year period, even after controlling for differences in observable firm characteristics. The estimated relationship is statistically significant only for exporting at *t+2*, suggesting that the benefits of faster Internet take time to materialise. The coefficient on UFB adoption barely changes when the principal components on ICT intensity and process focus are added (in Columns 3 and 4), as well as when the interactions between UFB adoption and the principal components are added (Column 5 and 6). In Column 5, we observe a positive coefficient on the interaction between UFB adoption and overall ICT intensity. Notwithstanding its relatively weak statistical significance, this coefficient suggests that only the firms with relatively high existing digital capabilities can benefit from faster Internet in the short run.

The overall estimation results above mask the heterogeneity across firm sizes. As discussed in the Section 2, UFB adoption can particularly help smaller firms to start exporting by reducing the fixed costs of export entry related to search and information costs. However, smaller firms often lack managerial capabilities to make the best use of digital tools (OECD, 2021b), which may limit the benefits of faster Internet speed. Table 5 presents the estimation results from the full models (corresponding to Columns 5 and 6 of Table 4) for separate samples of larger and smaller firms. Smaller firms are defined as firms with less than 20 employees, the number that is close to the median of the sample firms, thereby allowing us to split the sample almost evenly.

Among larger firms, UFB adoption is associated with export entry at *t+2*, but not at *t* (Column 1 and 2), consistent with the results for the full sample above. Furthermore, the principal component *ICT process focus* has a weak negative relationship with export entry at *t* (Column 1). The construction of this component is such that a negative coefficient implies that firms owning websites with more functions are more likely to enter exporting than those using ICT primarily to support their operational processes for the same overall intensity in ICT usage (see Table 3). In contrast, UFB adoption is directly associated with export entry at *t* but not at *t+2* among smaller firms (Column 3 and 4). One interpretation of this interesting

asymmetry is that smaller firms are more agile in reconfiguring their workflow to exploit faster Internet and start exporting than larger firms.

Table 4. Estimated coefficients for the probability of export entry (OLS)

	(1)	(2)	(3)	(4)	(5)	(6)
	Export at t	Export at t+2	Export at t	Export at t+2	Export at t	Export at t+2
Adopt UFB	0.032	0.060**	0.032	0.060**	0.032	0.059**
	(0.020)	(0.025)	(0.020)	(0.025)	(0.020)	(0.025)
ICT intensity			-0.002	0.003	-0.006	0.002
			(0.004)	(0.006)	(0.004)	(0.006)
ICT – process focus			0.001	-0.002	-0.000	-0.007
			(0.006)	(0.008)	(0.006)	(0.008)
Adopt UFB#ICT intensity					0.015*	0.006
					(0.009)	(0.015)
Adopts UFB#ICT process focus					0.004	0.017
					(0.014)	(0.018)
R-squared	0.052	0.039	0.052	0.039	0.054	0.041
N	1287	1056	1287	1056	1287	1056

Notes: The table summarises the estimated coefficients and their standard errors of the linear probability model (OLS) of the probability of exporting in year t and year t+2, conditional on being a non-exporter in year t-2. Base years (t) are 2012 and 2014. The estimation sample includes only firms that did not have Fibre connection at t-2 and is restricted to the firms in the following exporting industries: Agriculture, forestry and fishing; Manufacturing; Wholesale trade; Information media and telecommunications; Professional and technical services; and Administrative and support services. Control variables include firm characteristics at t-2 (the logarithm of the number of employees, labour productivity, average labour quality, a binary indicator of inward foreign direct investment, a binary indicator of outward direct investment, a binary indicator of R&D activity, natural logarithm of employment density in the area the firm is located, as well as year dummies and 1-digit ANZSIC06 industry dummies. *,**,*** correspond to statistical significance at 10%, 5% and 1% level respectively. Regression sample statistics are available in Annex B table A2.
Source: Authors' estimations.

Existing digital capabilities plays a more important role in the short run contribution of UFB adoption to export entry for smaller firms than in the full sample, as indicated by the larger and statistically significant coefficient on the interaction term between UFB adoption and the principal component *ICT intensity* (Column 3). Given the mean value of the component *ICT intensity* (-0.847) and its standard deviation (1.863), the estimated coefficients imply that a small firm with initial digital capabilities at the mean value of *ICT intensity* would see a 4 percentage point higher export probability at time *t* vis-à-vis a firm with the same level of *ICT intensity* that did not adopt UFB. In contrast, a firm with initial level of *ICT intensity* that is one standard deviation higher than the mean value would see 10.7 percentage points higher probability of export entry following UFB adoption vis-à-vis a firm with the same level of *ICT intensity* that did not adopt fibre. The role of initial digital capabilities is important in the long run as well: the weakly significant coefficient on the interaction term in Column 4 implies that only firms with sufficiently high initial levels of *ICT intensity* would see higher probability of exporting at *t+2* following their UFB adoption.

The contribution of faster Internet to export entry can also differ across industries depending on the nature of industrial activities. For instance, faster internet is more likely to promote the export of services that can be delivered online than of goods or services that can only be delivered though physical contact. Table 6 summarises the estimation of the full models (in Columns 5 and 6 of Table 4) for the subsamples of three combined industry groups: Goods (Manufacturing and Wholesale trade); Services (Information media and Telecommunications; Professional and Technical Services; and Administration and Support services) and

Advanced Services (Information media and Telecommunications; and Professional and Technical services).[16]

Table 5. Estimated coefficients for the probability of export entry (larger versus smaller firms)

	(1)	(2)	(3)	(4)
	All export industries			
	Large firms (>=20 employees)		Small firms (<20 employees)	
	Export at t	Export at t+2	Export at t	Export at t+2
Adopts UFB	0.001	0.074**	0.070**	0.057
	(0.026)	(0.035)	(0.034)	(0.039)
ICT intensity	-0.005	0.013	-0.005	-0.004
	(0.008)	(0.011)	(0.004)	(0.007)
ICT – process focus	-0.016*	-0.013	0.010	-0.002
	(0.010)	(0.012)	(0.008)	(0.012)
Adopts UFB#ICT intensity	-0.005	-0.032	0.036***	0.038*
	(0.014)	(0.022)	(0.013)	(0.021)
Adopts UFB#ICT process focus	0.015	0.023	0.005	0.013
	(0.016)	(0.025)	(0.026)	(0.026)
R-squared	0.114	0.089	0.035	0.036
N	582	504	702	552

Notes: See notes in Table 4. Sample statistics are available in Annex B table A3.
Source: authors' estimation.

The results in Table 6 Columns 1 and 2 indicate that UFB adoption by goods producing or trading firms is not followed by a higher probability of export entry. In contrast, UFB adoption is associated with higher export propensity for firms in the Services both in the short and long run (Columns 3 and 4). Interestingly, the two principal components characterising higher initial digital capabilities relate negatively to the export entry in *t*. These negative correlations are driven by the firms in Administrative and support services, which make up around 40% of the sample in the Services group. Finally, for the small group of firms in Advanced Services, UFB adoption is only related to higher export propensity in the long run (*t+2*) for firms with high initial digital capabilities, as indicated by the statistically significant coefficient on the interaction term between UFB adoption and the principal component *ICT intensity* (Column 6). Overall, the positive relationship between UFB adoption and export entry as well as the positive interaction between UFB adoption and existing digital capabilities reported for the whole sample (Table 4) seems to be driven by the sub-sample of firms belonging to the Services group. Firms in service industries, in particular, those belonging in the Advanced Services group, are smaller and have higher values of the principal component *ICT intensity* than goods producers (Annex B, Table A4). Our findings are in line with Kneller and Timmis's (2016), where the positive impacts of faster Internet are found only among firms providing professional and technical services, which can potentially be delivered digitally and are likely to require frequent communication with customers.

[16] We exclude Agriculture, forestry and fishing from the goods industry as many firms in this industry export indirectly through a processing firm, producer board, or other industry intermediaries.

Table 6. Estimated coefficients for the probability of export entry (by industry group)

	(1)	(2)	(3)	(4)	(5)	(6)
	Goods		Services		Advanced services	
	Export at t	Export at t+2	Export at t	Export at t+2	Export at t	Export at t+2
Adopts UFB	0.011	0.052	0.051*	0.067**	0.065**	0.048
	(0.033)	(0.041)	(0.026)	(0.033)	(0.028)	(0.033)
ICT intensity	-0.005	0.001	-0.014**	0.003	-0.009	-0.008
	(0.005)	(0.008)	(0.006)	(0.010)	(0.008)	(0.014)
ICT – process focus	0.008	-0.011	-0.014*	0.004	-0.005	0.016
	(0.008)	(0.013)	(0.008)	(0.012)	(0.008)	(0.014)
Adopts UFB#ICT intensity	0.004	-0.018	0.021	0.031	0.026	0.074**
	(0.013)	(0.025)	(0.018)	(0.026)	(0.020)	(0.032)
Adopts UFB#ICT process focus	-0.025	0.018	0.022	0.003	0.027	0.002
	(0.021)	(0.030)	(0.018)	(0.023)	(0.019)	(0.025)
R-squared	0.050	0.040	0.122	0.106	0.157	0.170
N	699	582	414	330	246	198

Notes: See notes in Table 4. The groups of industries are: Goods, comprising Manufacturing and Wholesale trade; Services, comprising Information media and telecommunications; Administrative and support services; Professional and technical services; and Advanced services, comprising Information media and telecommunications and Professional and technical services. Sample statistics are available in Annex B table A4.
Source: Authors' estimation.

Instrumental variables (IV) estimation

In this sub-section, we seek to assess the causality of the predictive relationships described above by instrumenting UFB adoption with the historical geographic variance in UFB availability. This approach is in line with previous studies that instrument a firm's broadband adoption with spatial differences in broadband availability, which are determined by the government's rollout plan and are therefore exogenous to firms. For instance, Akerman et al. (2015) instrumented the use of broadband by Norwegian firms with the share of households with access to broadband at each municipality level. They showed that broadband raises the productivity of Norwegian firms and that productivity gains are achieved through an increase in the relative productivity of skilled labour. Similarly, Canzian et al. (2019) used a staggered rollout of ADSL within Italy as an instrument and reported that the use of broadband boosts firm revenue and total factor productivity.

We construct the instrument variable by each firm's proximity to schools drawing on the methodology of Fabling and Grimes (2021) and incorporating regional differences in the timing of UFB rollout. This instrumental variable should be correlated with a firm's UFB adoption since adoption of UFB is largely driven by the availability at the firm's location, and a large share of New Zealand firms were located in areas that did not have access to fibre broadband in the early years of UFB rollout (Fabling and Grimes, 2021). At the same time, there is no obvious reason to expect that a firm's distance to the nearest school is correlated with export entry, since the location of schools in urban and rural areas is not determined by the agglomeration of industrial activities or other infrastructure. Other firm characteristics are treated as exogenous and included in the model in their lagged form, consistent with the event study models above.

We define a "UFB-enabled school" as a school located in a region where the UFB rollout already started.[17] For each firm, we calculate the minimum distance between the firm's location (at *t-2*, either 2010 or 2012)

[17] Fabling and Grimes (2021) use simple distance to a school, regardless of whether the UFB roll-out to that area was underway, and control for broad regional factors using the firm's employment share in each Territorial Authority. This approach works well for their analysis of changes in productivity, where a first or long difference model can be used to difference out permanent and unobserved firm characteristics. In contrast, our interest in the binary outcome of whether a firm exports or not requires that we include controls for a range of other firm characteristics known to affect export

and the nearest "UFB-enabled school" at *t* (2012 or 2014). This provides us with a reasonable proxy for each firm's access to UFB in the two-year leading up to potential adoption at time *t*.

The first-stage estimation for our IV estimation is the following:

$$P(Adopts\ UFB_{it}=1) = \alpha + \beta_1\ UFB\ School\ Distance_{it} + \gamma Z_{t-2} + \phi_t + \varepsilon_{it} \quad (3)$$

Where *UFB School Distance*$_{it}$ is the log of the minimum distance (in kilometres) between the centre of the meshblock where the firm is located and the centre of the meshblock the nearest UFB-enabled school is located. Z_{t-2} is the vector of firm characteristics and ϕ_t is a vector of year dummies.

Meshblocks are the smallest geographic unit available in the Business Register. Because they are defined on the basis of population, they range from around the size of a city block to over 2000 square kilometres in sparsely populated rural areas. For firms located in the same meshblock as the nearest school, *UFB School Distance*$_{it}$ is set to 10m. While this approach substantially underestimates the true distance to schools for firms in rural areas, the weight of firms affected by this treatment is small as rural firms make up a small fraction of our sample. The exclusion of these firms does not affect our results.

We also estimate a model where we include employment density as an additional instrument for UFB adoption, to allow for the possibility that UFB roll-out prioritised areas with dense economic activity in addition to the prioritisation of schools and hospitals. While employment density may be correlated with export entry, given that agglomeration of economic activities generates knowledge spillovers that facilitate exports (Fabling, Grimes and Sanderson 2012), the coefficient on this variable was never statistically significant in the estimation of the event study model. Anderson-Rubin tests of overidentification also suggest that employment density is indeed a valid instrument alongside *UFB School Distance*$_{it}$ (Table **7**).

Table **7** presents the estimation results from both models for the full sample of export industries, estimated by Limited Information Maximum Likelihood (LIML) method. The first stage IV coefficients indicate that firms located closer to UFB-enabled schools in 2010 or 2012 were indeed more likely to have adopted UFB by 2012 or 2014, even after controlling for other firm characteristics. For instance, a 1% smaller distance to the nearest school is associated with around a 3 percentage point higher probability of UFB adoption. However, although the school distance variable is a statistically significant predictor of UFB uptake, it explains only a small part of the variation in UFB adoption across firms. Inclusion of employment density as a second instrument slightly strengthens the instruments relative to the Stock-Yogo critical values (Column 3 and 4).

Estimates in the second stage regression for the effect of UFB adoption on export entry are implausibly large, for instance indicating an 18 percentage point increase in the probability of export entry points as the result of UFB adoption (column 1). Except in Column 3, the coefficient on UFB adoption is not statistically significant due to large standard errors, a typical symptom of weak instruments. This contrasts with the statistically significant and economically plausible estimates obtained from the OLS estimation. [18]

All in all, the lack of plausible and statistically significant effects of random UFB adoption suggests that the positive relationship between UFB adoption and export entry reported in the event study model (Tables 4 to 6) is driven primarily by the non-random selection of firms into UFB adoption. That is, either UFB uptake

success. Once these additional firm-level variables are included in the model, the simple school distance variable remains strongly and negatively associated with UFB uptake (firms closer to schools are more likely to adopt, even after controlling for other observable characteristics), but is not a sufficiently strong predictor to overcome the weak instruments problem. We therefore supplement the simple measure with additional information on the timing of the roll-out, giving sufficiently strong instruments in a subset of our estimation samples.

[18] We also tested an alternative IV specification that instruments UFB adoption with the distance to the nearest school that does not incorporate the timing of UFB roll out, but instead restricts the sample to firms located in regions where the UFB has been already rolled out. This yielded coefficients on UFB adoption that are weakly statistically significant in some cases (notably for smaller firms) but are still implausibly large.

was strongest among firms that would have had higher export propensity regardless of UFB uptake, or early adopters of UFB correctly anticipated that it would facilitate their export entry and improve their productivity. Since this result may not carry over to later adopters, the event study results represent an upper bound of the possible effect of UFB adoption on export entry. [19]

Table 7. Instrumental variable regression results for probability of export entry (LIML)

	(1)	(2)	(3)	(4)
	Export at t	Export at t+2	Export at t	Export at t+2
First stage IV estimation				
ln(UFB school distance)	-0.031***	-0.026***	-0.031***	-0.026***
	(0.006)	(0.007)	(0.006)	(0.007)
ln(local employment density)			0.008	0.011*
			(0.006)	(0.007)
Second stage IV estimation				
Adopts UFB	0.183	0.306	0.208*	0.128
	(0.140)	(0.214)	(0.119)	(0.157)
First stage partial R2	0.018	0.012	0.026	0.022
IV F-stat	23.25	12.75	16.57	11.58
Stock-Yogo critical values for the Cragg-Donald F-statistic (10% test size)	16.38	16.38	8.680	8.680
Anderson-Rubin overidentification test statistic			0.102	1.812
			(p = 0.749)	(p = 0.178)
Observations	1,287	1,056	1,287	1,056

Notes: This table summarises the estimated coefficients from a limited information maximum likelihood (LIML) instrumental variable estimation of the impact of UFB adoption on export entry. Columns 1 to 3 include one instrument (log of UFB school distance), with local employment density included as a control variable. Columns 4 to 5 additionally include the log of local employment density as a second instrument. Models include controls for firm characteristics and year and 1-digit ANZSIC06 industry fixed effects, for the sample of export-intensive industries. See notes to table 4 for further details.
Source: Authors' estimation.

Conclusion

This paper explores the relationship between faster Internet and export entry. The Internet promotes international trade by allowing timely transmission of information between parties and thereby reducing search and information frictions, which are considered a primary source of high export market entry costs. However, digital technologies have evolved dramatically over the past decades, offering tools that further reduce information asymmetries and improve productivity. It is important to understand whether faster Internet, such as fibre broadband, exerts an additional role in promoting exports by enabling the use of these data-intensive digital tools that require fast transmission of large data. Whether faster Internet facilitates exports is also an important question for assessing the economic gains from the policy initiatives across OECD countries to roll out high-speed broadband, such as New Zealand's Ultra-Fast Broadband (UFB) initiative.

This paper finds that adoption of fibre-to-premise by New Zealand firms helps to predict their export entry, and that this relationship is observed mainly among services firms, which are relatively small and some of

[19] Indeed, we do not obtain a significant coefficient on UFB adoption when we estimate the event study model for firms adopting UFB in 2014 and 2016, rather than 2012 and 2014.

their products can be delivered over the Internet. The rich information on the ICT use in our data enables us to include proxies from firms' capabilities in leveraging the Internet and digital tools prior to their adoption of UFB. We find that the relationship between UFB uptake and export entry was disproportionally larger for firms that were already intensive users of Internet-based technologies. However, firms that chose to adopt high-speed Internet during the early phase of the UFB rollout may not have done so randomly but instead were likely motivated by the potential benefits of UFB adoption, including its potential in reducing the barriers to exporting. If this is the case, the positive relationships between UFB uptake and export entry can be driven at least partly by the self-selection of firms with such advanced foresight. Similarly, there may be other unobserved differences between firms driving both UFB adoption and export entry. Our instrument variable estimation could not exclude such a possibility.

This paper has important implications for policies promoting the roll out of faster Internet. On the one hand, better access to faster Internet could help countries improve their export performance, which would be an important return to investment in high-speed broadband infrastructure. On the other hand, the extent of this return is defined by the digital capabilities of firms, that is their existing capacity to exploit digital and Internet-based tools intensively. It is therefore essential to match the infrastructure investment in high-speed broadband with policy measures to enhance firms' digital capabilities. For instance, New Zealand launched the Digital Boost initiative in 2021 to support digital take-up by small businesses. This scheme should provide not only training for digital skills but also managerial consultation that helps firms develop competent digitalisation and export strategies that leverage fast Internet and digital technologies.

References

Abeliansky, A. L. and M. Hilbert. (2017) "Digital technology and international trade: Is it the number of subscriptions or the quality of data speed that matters?", *Telecommunications Policy,* Vol. 41 (1), 35-48.

Abowd, J. M., Creecy, R.H. and F. Kramarz (2002), "Computing Person and Firm Effects Using Linked Longitudinal Employer-Employee Data", *Technical Paper,* No. TP-2002-06, US Census Bureau, Washington D.C.

Akerman, A., Leuven, E. and M. Mogstad (2022), "Information Frictions, Internet and the Relationship between Distance and Trade", *American Economic Journal: Applied Economics,* Vol.14(1), 133-163.

Akerman, A., Gaarder, I. and M. Mogstad (2015), "The Skill Complementarity of Broadband Internet", *The Quarterly Journal of Economics,* Vol.130 (4), 1781-1824.

Bernard, A. B., and B. J. Jensen (1999), "Exceptional exporter performance: cause, effect, or both?" *Journal of International Economics*, Vol. 47 (1), 1-25.

Black, S. E., and L. M. Lynch (2001), "How to compete: The impact of workplace practices and information technology on productivity", *Review of Economics and Statistics,* Vol.83 (3), 434-445.

Bloom, N. et al. (2021), "Trade and Management", *The Review of Economics and Statistics,* Vol.103 (3), 443-460.

Bloom, N. et al. (2020), "Do management interventions last? Evidence from India", *American Economic Journal: Applied Economics,* Vol.12 (2), 198-219.

Bloom, N. et al. (2014), "The distinct effects of information technology and communication technology on firm Organization", *Management Science,* Vol.60 (12), 2859-2885.

Bloom, N., Sadun, R. and J. van Reenen (2012), "Americans do IT better: US multinationals and the productivity miracle", *American Economic Review,* Vol.102 (1), 167-201.

Blum, B. S. and A. Goldfarb (2006), "Does the internet defy the law of gravity?", *Journal of International Economics,* Vol.70 (2), 384-405.

Brynjolfsson, E., Rock, D. and C. Syverson (2021), "The Productivity J-Curve: How Intangibles Complement General Purpose Technologies", *American Economic Journal: Macroeconomics,* Vol.13 (1), 333-372.

Brynjolfsson, E., Hitt, L.M. and S. Yang (2002), "Intangible Assets: Computers and Organizational Capital", *Brookings Papers on Economic Activity: Macroeconomics,* Vol.1, 137-199.

Caliendo, L. and E. Rossi-Hansberg (2012), "The impact of trade on organization and productivity", *Quarterly Journal of Economics,* Vol.127 (3), 1393-1467.

Caliendo, L., Monte, F. and E. Rossi-hansberg (2018), "Growth , Productivity and Employment Edited by Exporting and organizational change", in Ing, L.Y. and M. Yu (eds) *World Trade Evolution Growth, Productivity and Employment*, Routledge, London.

Canzian, G., Poy, S. and S. Schüller (2019), "Broadband upgrade and firm performance in rural areas: Quasi-experimental evidence", *Regional Science and Urban Economics,* Vol. 77: 87-103.

Cardona, M., Kretschmer, T. and T. Strobel (2013), "ICT and productivity: Conclusions from the empirical literature", *Information Economics and Policy,* Vol. 25 (3), 109-125.

Corrado, C. et al. (2021), "New evidence on intangibles, diffusion and productivity", *OECD Science, Technology and Industry Working Papers* No. Chap. 2021/10, OECD Publishing, Paris.

Crespi, G., Criscuolo, C. and J. Haskel (2007), "Information Technology, Organisational Change and Productivity Growth: Evidence from UK Firms", *CEP Discussion Paper*, No.783

Crown Infrastructure Partners (2021), *Quarterly Connectivity Update Q2: to 30 June 2022.*

De Serres, A., Yashiro, N. and H. Boulhol (2014), "An International Perspective on the New Zealand Productivity Paradox", *Working Paper* No.2014/01 New Zealand Productivity Commission, Wellington.

Disdier, A. and K. Head (2008), "The Puzzling Persistence of the Distance Effect on Bilateral Trade", *The Review of Economics and Statistics,* Vol. 90 (1), 37-48.

Fabling, R. and A. Grimes (2021), "Picking up speed: Does ultrafast broadband increase firm productivity?", *Information Economics and Policy,* In print.

Fabling, R. and A. Grimes (2014), "The "Suite" Smell of Success: Personnel Practices and Firm Performance." *ILR Review* , Vol.67 (4), 1095-1126.

Fabling, R., Grimes, A. and L. Sanderson (2012) "Whatever next? Export market choices of New Zealand firms", *Papers in Regional Science*, Vol. 91 (1), 137-159.

Fabling, R. and D. C. Maré (2015), "Addressing the absence of hours information in linked employer-employee data ", *Motu Working Paper* No. 15-17. Motu Economic and Public Policy Research, Wellington.

Fabling, R. and L. Sanderson (2016), "A Rough Guide to New Zealand's Longitudinal Business Database", *Motu Working Paper* No.16-03, Motu Economic and Public Policy Research, Wellington.

Fabling, R. and L. Sanderson (2013), "Exporting and firm performance: Market entry, investment and expansion", *Journal of International Economics,* Vol. 89 (2), 422-431.

Fernandes, A. M. et al. (2019), "The internet and Chinese exports in the pre-ali baba era", *Journal of Development Economics,* Vol.138, 57-76.

Freund, C. L. and D. Weinhold (2004), "The effect of the Internet on international trade", *Journal of International Economics,* Vol. 62 (1), 171-189.

Freund, C. L. and D. Weinhold (2002), "The Internet and International Trade in Services", *American Economic Review,* Vol. 92 (2), 236-240.

Garicano, L. (2010), "Policemen, managers, lawyers: New results on complementarities between organization and information and communication technology", *International Journal of Industrial Organization,* Vol. 28 (4), 355-358.

Gkypali, A., Love, J. H. and S. Roper (2021), "Export status and SME productivity: Learning-to-export versus learning-by-exporting", *Journal of Business Research,* Vol.128 (March), 486-498.

Hagsten, E and P. Kotnik (2017), "ICT as facilitator of internationalisation in small- and medium-sized firms", *Small Business Economics,* Vol. 48 (2), 431-446.

Jolliffe, I. T. and J. Cadima (2016), "Principal component analysis: a review and recent developments", *Phylosophical Transaction of the Royal Society,* Vol.A 374 (2065).

Kneller, R. and J. Timmis (2016), "ICT and Exporting: The Effects of Broadband on the Extensive Margin of Business Service Exports", *Review of International Economics,* Vol. 24 (4), 757-796.

Lawless, M. (2010), "Deconstructing gravity: trade costs and extensive and intensive margins" *Canadian Journal of Economics/Revue canadienne d'économique*, Vol. 43 (4), 1149-1172.

Lileeva, A. and D. Trefler (2010), "Improved access to foreign markets raises plant-level productivity. . .for some plants", *Quarterly Journal of Economics*, Vol. 125 (3), 1051-1099.

Lin, F. (2014), "Estimating the effect of the Internet on international trade", *The Journal of International Trade & Economic Development*, Vol.24 (3), 409-428.

Maré, D. C., Hyslop, D.R. and R. Fabling (2016), "Firm productivity growth and skill", *New Zealand Economic Papers*, Vol. 51 (3), 302-326.

Melitz, M.J. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica*, Vol. 71(6), 1695-1725.

New Zealand Productivity Commission (2021), *New Zealand firms: reaching for the frontier.*

OECD (2022), *Economic Survey: New Zealand 2022.* Paris: OECD Publishing.

OECD (2021a), *Strengthening Economic Resilience Following the COVID-19 Crisis: A Firm and Industry Perspective.* OECD Publishing, Paris.

OECD (2021b), "The Digital Transformation of SMEs." *OECD Studies on SMEs and Entrepreneurship*. OECD Publishing, Paris.

OECD (2020), *OECD Digital Economy Outlook 2020.* OECD Publishing, Paris.

Osnago, A. and Tan, S.W. (2016), "Disaggregating the Impact of the Internet on International Trade", *Policy Research Working Paper*, No.7785, World Bank Group, Washington D.C.

Rajan, R. G. and L. Zingales (1998), "Financial Dependence and Growth", *American Economic Review,* Vol.88 (3), 559-586.

Ricci, L. A. and F. Trionfetti (2012), "Productivity, networks, and export performance: Evidence from a cross-country firm dataset", *Review of International Economics,* Vol. 20 (3), 552-562.

Sun, M. (2021), "The Internet and SME Participation in Exports", *Information Economics and Policy,* In print.

Visser, R. (2019), "The effect of the internet on the margins of trade", *Information Economics and Policy,* Vol. 46, 41-54.

Annex A. Business Operation Survey questions

Questions on international engagement and R&D (Module A, annual)

6 For the last financial year, estimate the proportion of this business's sales of goods and services that came from exports:

Note: Please round to the nearest %. If your exports are between 0 and 1%, please round up to 1%.

[ ][ ][ ] %

A0601

9 For the last financial year, did this business undertake or fund any research and development (R&D) activities?

Include:
- any activity characterised by originality: it should have investigation as its primary objective, and an outcome of gaining new knowledge, new or improved materials, products, services, or processes
- the buying abroad of technical knowledge or information

Don't include:
- market research
- efficiency studies
- style changes to existing products

1 yes → go to **10**
2 no → go to **12**
3 don't know → go to **12**

A0900

12 As at the end of the last financial year, did any individual or business located overseas hold an ownership interest or shareholding in this business?

1 yes → please give the total percentage: [ ][ ][ ] % A1201
2 no
3 don't know

A1200

13 As at the end of the last financial year, did this business hold any ownership interest or shareholding in an overseas located business (including its own branch, subsidiary or sales office)?

1 yes → go to **14**
2 no → go to **15**
3 don't know → go to **15**

A1300

Questions on ICT USE (Module B, biennial in even years)

14 Mark all that apply. What types of broadband Internet connection does this business use?

- DSL including ADSL (provided over your copper telephone line) B1401
- cable (eg cable plans available in Wellington and Christchurch) B1402
- fibre-to-the-premise (fibre optic broadband network) B1403
- cellular technology B1404
- wireless B1405
- satellite B1406

or don't know B1407

18 Mark all that apply. For which of the following activities, if any, does this business use the Internet?

- finance (eg on-line banking, invoicing, making payments) B1801
- internal or external recruitment (eg details of vacant positions on an intranet or website) B1802
- staff training (eg e-learning applications available on an intranet or the Internet) B1803
- sharing information within your business (eg intranet, knowledge management software) B1804
- sharing information with other organisations (eg collaboration with business partners) B1805

or no, the Internet is not used for any of these activities B1806

20 In the last financial year, did this business use the Internet to place orders to purchase goods or services?

Include:
- capital and current purchases (eg travel and other services, office supplies, equipment)
- orders placed via the Internet whether or not payment was made on-line
- orders placed via websites, specialised Internet marketplaces, and extranets

Don't include:
- orders submitted via conventional email
- orders which were cancelled or not completed

1 yes

2 no

3 don't know B2000

21 In the last financial year, did this business use the Internet to receive orders to sell goods or services?

Include:
- orders received on behalf of other businesses, and orders received by other businesses on behalf of this business
- orders received via the Internet whether or not payment was made on-line
- orders received via websites, specialised Internet marketplaces, and extranets

Don't include:
- orders submitted via conventional email
- orders which were cancelled or not completed

1 yes → go to **22**
2 no → go to **25**
3 don't know → go to **25**

B2100

Web presence

25 Does this business have a website, homepage, or other web presence?

Include a presence on another entity's website if this business has **substantial control** over the content of the page.
Don't include listings in an on-line directory.

1 yes → go to **26**
2 no → go to **27**

B2500

26 Mark all that apply. Which of the following features and facilities are offered on this business's web presence(s)?

- goods or services information or prices B2601
- facility for collecting customer information on-line B2602
- on-line ordering facility for this business's goods or services B2603
- facility for on-line payment B2604
- provision of on-line after sales support (eg on-line queries, customer feedback) B2605
- customised web page or information provided for repeat customers B2606
- information about privacy or security (eg privacy or security policy statements) B2607

Impact of ICT

9 Mark all that apply. Has this business's **use of ICT** been important in achieving any of the following outcomes?

- improved responsiveness to customer needs (eg customised goods or services) B0901
- greater understanding of markets (eg analysing customer purchasing patterns) B0902
- better sales or marketing methods B0903
- introduced goods or services not possible without ICT B0904
- reduced prices from suppliers (eg through ability to shop around) B0905
- improved efficiency of work flow, inventory management, or ordering systems (eg just-in-time processes) B0906
- better coordination of staff and business activities B0907
- improved efficiency of production processes (eg due to reduced downtime or automation) B0908
- improved management of quality B0909
- improved management information systems (eg real-time performance monitoring) B0910
- reduced costs of entering new markets B0911
- shifted activities to other businesses (eg contracting out payroll functions) B0912
- improved collaboration with other businesses (eg on joint development or marketing) B0913

or none of the above B0914

10 Mark all that apply. In the **last 2 financial years**, has this business done any of the following activities **to get more benefit from its ICT**?

- changed staff levels or skills mix B1001
- trained employees B1002
- introduced new work practices (eg teamworking) B1003
- restructured the organisation B1004
- implemented new business strategies or management techniques B1005
- physically relocated any business activities B1006
- invested in capital other than ICT B1007
- performed research and development B1008
- redesigned processes for producing or distributing goods or services B1009
- shifted production towards goods or services that use ICT more intensively B1010

or no, none of the above were done to increase the benefits of ICT B1011

Questions on Overseas sales of goods and services (Module C, 2019)

2 Mark one oval for each row. In the last financial year, to which markets did this business sell the following goods and services?

Mark "not applicable" if your business does not sell the listed goods or services.

	NZ only	overseas only	NZ and overseas	not applicable	
raw, unprocessed materials	1	2	3	4	C0201
manufactured or finished goods	1	2	3	4	C0202
services	1	2	3	4	C0203
technology and licences for use of intellectual property	1	2	3	4	C0204
other	1	2	3	4	C0205

3 Did this business mark "**overseas only**" or "**NZ and overseas**" for any options in question **2** above?

1 yes → go to **4**
2 no → go to **12** C0300

8 Mark all that apply. In the last financial year, how did this business market its products overseas?

- overseas visits and/or trade fairs C0801
- word of mouth from existing customers C0802
- through our own website C0803
- through a third party online marketplace (eg Amazon, Alibaba) C0804
- through other online advertising or social media C0805
- advertising in other overseas media (e.g. printed media or television) C0806
- other C0807
- no active marketing strategy C0808

9 Mark all that apply. In the last financial year, which of the following methods did this business use to deliver goods and services to overseas customers?

- delivered via air or sea freight C0901
- overseas customers travelled to NZ C0902
- employees of this business travelled overseas C0903
- supplied by overseas subsidiaries of this business C0904
- supplied via the Internet or telephone C0905
- other C0906

Annex B. Variable definitions and summary statistics for the estimation samples

Table A1: Variable definitions

Descriptive variable name	Definition	Source data
Exporter	Binary variable set to 1 if firm reports >1% of sales are exported, 0 otherwise	BOS Module A
Adopts fibre	Binary variable set to 1 if firm reports using fibre-to-the-premise connection in year t but not in year t-2	BOS Module B, ICT
ICT intensity	Principal component capturing internet use (see section 4)	BOS Module B, ICT
ICT process focus	Principal component capturing internet use (see section 4)	BOS Module B, ICT
Labour	Firm size as measured by average employment during the year (mean monthly headcount of employees plus adjusted annual count of working proprietors)	Fabling and Maré (2015) Labour tables
Average labour quality	Firm-level average of individual "labour quality" measure based on two-way worker-firm fixed effects model (Maré, Hyslop and Fabling 2016; Abowd, Creecy and Kramarz 2002). We aggregate individual human capital measures to the firm level by combining the average worker fixed effects (unobservable skills) and the average estimated age-gender wage premia (experience effects) for all individuals working for the firm in each year	Fabling and Maré (2015) Labour tables
Labour productivity	Labour productivity defined as log((gross output-intermediate consumption)/L)	Fabling and Maré (2015b,2019) Productivity tables
ODI	Binary variable set to 1 if firm reports holding an ownership interest or shareholding in an overseas located business	BOS Module A
FDI	Binary variable set to 1 if firm reports that an individual or business located overseas holds an ownership interest or shareholding	BOS Module A
R&D	Binary variable set to 1 if firm reports undertaking or funding R&D activities in the last financial year	BOS Module A
ln(local employment density)	Log of employment density (employees per square kilometre) in the Area Unit in which the firm is located at t-2. Top 1 percent of employment densities Winsorised to exclude implausible values. For firms with multiple locations, the highest density location is used.	Firm locations from Longitudinal Business Frame combined with employee counts from Fabling and Maré (2015) Labour tables.
ln(UFB school distance)	Log of distance to the nearest school, where that school is in a district where the national UFB rollout had commenced by t.	Firm locations from Longitudinal Business Frame combined with rollout information provided by Crown Infrastructure Partners
ANZSIC06 1-digit industry code	One-digit Australia New Zealand Standard Industrial Classification 2006	Business Operations Survey (from Stats NZ sampling frame)

Table A2: Summary statistics for the main regression sample

	Export industries, outcomes at t		Export industries, outcomes at t+2	
	Mean	Std dev	Mean	Std Dev
Has fibre at t	0.219		0.227	
Exports	0.072 (at t)		0.091 (at t+2)	
ICT intensity (at t-2)	-0.511	1.863	-0.480	1.828
ICT process focus (at t-2)	-0.169	1.204	-0.155	1.217
ln(labour)	3.052	1.047	3.093	1.039
Labour	45.455	114.886	45.515	107.646
Average labour quality	10.562	0.191	10.550	0.187
Labour productivity	11.341	0.646	11.345	0.618
ln(local employment density)	6.784	2.554	6.741	2.588
ln(UFB school distance)	-0.109	1.955	-0.121	1.926
ODI	0.030		0.031	
FDI	0.084		0.082	
R&D	0.091		0.096	
Agriculture, Forestry and Fishing	0.131		0.130	
Manufacturing	0.417		0.419	
Wholesale trade	0.126		0.130	
Information Media and Telecommunications;	0.061		0.059	
Professional and Technical Services	0.133		0.136	
Administrative and Support Services	0.131		0.122	
Number of observations	1287		1056	

Table A3: Key summary statistics by firm size

	Large firms				Small firms			
	Outcomes at t		Outcomes at t+2		Outcomes at t		Outcomes at t+2	
	Mean	Std dev	Mean	Std Dev	Mean	Std dev	Mean	Std Dev
Has fibre at t	0.303		0.296		0.154		0.163	
Exports	0.082 (at t)		0.089 (at t+2)		0.068 (at t)		0.087 (at t+2)	
ICT intensity (at t-2)	-0.108	1.782	-0.125	1.751	-0.847	1.863	-0.806	1.838
ICT process focus (at t-2)	0.112	1.191	0.077	1.192	-0.403	1.164	-0.368	1.202
Number of observations	582		504		702		552	

Table A4: Summary statistics by industry

	Goods industries				Services industries				Advanced services industries			
	Outcome at t		Outcome at t+2		Outcome at t		Outcome at t+2		Outcome at t		Outcome at t+2	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Has fibre at t	0.189		0.196		0.319		0.324		0.402		0.409	
Exports	0.082 (at t)		0.113 (at t+2)		0.058 (at t)		0.063 (at t+2)		0.061 (at t)		0.076 (at t+2)	
ICT intensity (at t-2)	-0.462	1.750	-0.414	1.729	0.145	1.716	0.108	1.674	0.433	1.530	0.437	1.516
ICT process focus (at t-2)	-0.240	1.167	-0.226	1.182	0.103	1.289	0.104	1.314	0.191	1.406	0.207	1.429
ln(labour) (at t-2)	3.036	1.028	3.091	1.039	3.186	1.133	3.147	1.094	2.981	0.916	3.012	0.918
Number of observations	699		582		414		330		246		198	