Motu

Ultra-fast broadband, skill complementarities, gender and wages

Richard Fabling and Arthur Grimes

Motu Working Paper 19-23

Motu Economic and Public Policy Research

December 2019

Document information

Author contact details

Richard Fabling

Independent Researcher

richard.fabling@xtra.co.nz

Arthur Grimes

Motu Economic & Public Policy Research, & Victoria University of Wellington

PO Box 24390, Wellington 6142

arthur.grimes@motu.org.nz

Acknowledgements

We gratefully acknowledge funding from Huawei New Zealand that enabled this research to be conducted. Huawei had no input into any aspect of the analysis. We thank the Ministry of Business, Innovation and Employment (MBIE) for enabling access to the data, and Dave Maré for helpful advice.

Abstract

We examine whether ultra-fast broadband (UFB) has selective complementarities with certain types of labour. Using longitudinal data on New Zealand firms' internet connection type (UFB versus other forms of broadband) we find that, following UFB adoption by a firm, the wages of certain skilled incumbent employees rise. This is particularly so for males with STEM qualifications, plus males with university level qualifications (and possibly Masters level female graduates) without STEM qualifications. Wages of male employees without qualifications and of female employees with both lower level and no qualifications tend to fall relative to those in firms that do not adopt UFB. These results are consistent with the existence of skill-biased technical change. More puzzling is why these skill-biased changes have differential effects for incumbent male versus female workers.

JEL codes

D22, H54, J24, O33

Keywords

Broadband, ultra-fast, wages, skill-biased technical change, gender wage gap

Summary haiku

Ultra-fast broadband
a flowering of earnings
for some but not all

Motu Economic and Public Policy Research

PO Box 24390 info@motu.org.nz +64 4 9394250
Wellington www.motu.org.nz
New Zealand

 ISSN 1176-2667 (Print), ISSN 1177-9047 (Online).

Table of Contents

List of Tables and Figures

1 Introduction

We address the issue of whether ultra-fast broadband (UFB) has selective complementarities with certain types of labour. If it does, then UFB adoption following the provision of fibre to an area, will result in higher wages for certain types of employees of adopting firms. If it is a substitute for certain worker types (e.g. if it assists the out-sourcing of certain types of work) then those workers may receive a wage reduction or slower wage growth following UFB adoption.

Our analysis uses the central government led roll-out of fibre in New Zealand as the basis to study the impact of firm UFB adoption on the wages paid to their incumbent employees. Mirza and Beltrán (2014) and Fabling and Grimes (2016) describe the key properties of the central government's fibre initiative, begun in 2011. The initiative was designed to improve outcomes in schools and hospitals with benefits also for firms and households located sufficiently close to the fibre network to utilise it for UFB. Prior to this initiative, only small parts of the country had access to fibre for UFB. We use detailed official unit record data to estimate the relationship between firm UFB adoption and wages paid to different worker types. Our access to longitudinal data on firms' UFB (and other forms of broadband) use, plus other firm characteristics, wages paid and employee characteristics enables a panel estimation approach in which we observe not just firm access to the internet but also its adoption of UFB over time. The ability to observe firm adoption of UFB, together with the wages and characteristics of its incumbent workers over four successive biennial waves, takes the analysis well beyond earlier cross-sectional studies of these issues.

Early studies in the field used cross-sectional data to demonstrate a positive association between firm use of broadband (of any type) and firm productivity. For instance, Grimes et al. (2012) used propensity score matching to demonstrate that New Zealand firms which utilised broadband had greater productivity than did firms with only dial-up access to the internet. Akerman et al. (2015) used geographic availability of broadband as an exogenous source of variation in order to identify the effects of broadband use on Norwegian firms' productivity, skill mix (of labour) and wages paid to workers with different skills. The third of these aspects is most relevant to our research focus. They found evidence to suggest that broadband is complementary to skilled labour and is a substitute for unskilled labour with wages of the former group being higher, and those of the latter group being lower, than workers in firms without access to broadband.

Access speeds for early forms of internet ranged from 56 Kbps for dial-up to 256 Kbps in the first forms of ADSL[1] broadband which used the existing copper network. By contrast, UFB

[1] ADSL stands for asymmetric digital subscriber line. Kbps is kilobytes per second; Mbps is megabytes per second.

access initially offered download speeds in excess of 100Mbps and upload speeds of at least 50 Mbps (New Zealand Government, 2011); and much faster speeds are now available (European Commission, 2016).

The arrival and subsequent rapid adoption of UFB, in place of much slower forms of broadband, makes it important to assess whether the provision of fibre for ultrafast broadband has led to further positive outcomes for firms and workers relative to the effects identified for initial broadband adoption. It is also important to assess whether the same pattern of complementarities and substitutabilities arise as in the Akerman et al. study relating to early broadband types. It is noteworthy that a 2019 review paper on digital economics (Goldfarb and Tucker, 2019) still makes no reference to UFB, ultra-fast broadband, or fibre/fiber. Similarly, a 2015 review paper on broadband technologies (Bertschek et al., 2015) makes no reference to any study that evaluates the effect on firm performance of these much faster forms of broadband.[2] An extended period of panel data enables us to extend cross-sectional methods to a longitudinal analysis, and to identify the effects of UFB adoption relative to slower forms of broadband.

Our paper draws on the same data sources (with an extended timeframe) as Fabling and Grimes (2016). That analysis documented multi-factor productivity gains of around six percent for firms that adopted both UFB and that implemented management practices that were designed to take advantage of UFB adoption. Notably, they found that firms which adopted UFB but which did not implement new practices to leverage the new technology, made no productivity gains as a result of UFB adoption. This prior analysis suggests that wage gains for employees in firms that adopt UFB are likely, on average, to be less than six percent given that productivity gains may be shared between capital and labour, and that not all firms adopt complementary management practices. The analysis also raises the possibility that gains may be greater for workers who are responsible for designing or implementing complementary management practices that leverage UFB adoption.

In the education field, Grimes and Townsend (2018) found that UFB adoption in New Zealand led to statistically significant (albeit slight) improvements in academic outcomes for primary (elementary) aged school children across a range of subjects. That outcome can be considered an indicator of productivity improvement within schools arising from UFB adoption. Each of these prior studies used the (New Zealand government-sponsored) roll-out of fibre to schools as a main source of identification of effects of UFB adoption on outcomes.

In this study we extend prior analyses to examine which types of worker (if any) benefit from firm adoption of UFB. In particular, we split workers by gender, qualification level and qualification type (STEM[3] versus other) to test whether UFB is a complementary input for

[2] A study by Ahlfeldt et al. (2017) on the effects of fast (but not ultra-fast) broadband on residential property prices is cited.
[3] STEM stands for science, technology, engineering and mathematics.

certain worker types. This split is much richer than was available for the Akerman et al. study which (while controlling for gender) did not test whether effects differed between males and females. Nor was that study able to test whether impacts differed according to the type of the worker's qualification (i.e. their subject of study).

We employ a fixed effects panel approach in which fixed effects are included for each 'job', representing the match of a worker to a specific firm. The wage impacts on incumbent workers are identified from their firm's adoption of UFB (and, less commonly, cessation of UFB use), i.e. from changes in firms' internet access mode during the term of employment of the worker at that firm. It is unlikely, at least for most workers, that a worker will have any influence on their firm's decision to adopt UFB so the UFB adoption decision is generally exogenous to the worker. For one specification, we supplement this approach with instrumental variables estimates in which the firm's distance to the nearest school (which were prioritised for early UFB provision by government) is used to predict fibre adoption. In all cases, we subset only on a worker's continuing job in a single firm in order to avoid causality issues associated with endogenous worker decisions to move to other firms based (in part) on UFB usage.

We find that some, but not all, types of worker receive higher wages after their employer adopts UFB. In particular, men with at least post-school diplomas and men with STEM qualifications (at any level) receive higher wages once their firm has adopted UFB. Conversely, there is little evidence of wage benefits accruing to females with similar qualifications and skills. Workers with no qualifications (and particularly women) experience lower wages (or lower wage growth) following firm UFB adoption. While statistically significant, none of the effects is large: we find up to a 2% wage premium for suitably qualified males and a less than 1% wage reduction for unskilled females. These orders of magnitude are similar to the productivity gains found by Grimes and Townsend (2018) in relation to school achievement. The results point to fibre being a specific source of skill-biased technical change (Autor et al., 2003; Goos, 2018; Graetz and Michaels, 2018). The results also point to a technology-related factor that may contribute to the wage gap between men and women (Blau and Kahn, 2017; Sin et al., 2017).

Section 2 of the paper details our rich data sources and provides descriptive statistics on the firms and workers included in our dataset. In section 3, we analyse firm adoption (and use) of UFB over our sample period. Section 4 outlines our methodology for estimating the relationship between wages and UFB adoption, and presents empirical estimates of this relationship. Section 5 concludes with added interpretation of the empirical findings and suggestions for potential further analysis.

2 Data

Our data are obtained from Stats NZ's Longitudinal Business Database (LBD) and Integrated Data Infrastructure (IDI). The LBD comprises both official survey data and administrative records (including firms' tax records). Fabling and Sanderson (2016) describe key details of the LBD. Tax identifiers link the firm data (e.g. on surveyed broadband type, industry and firm size) with augmented worker data (e.g. for a worker's wages, and their qualifications, gender and age) from the IDI.[4] We observe the worker-firm linkage so we know when workers shift firms and/or shift into or out of employment. The longitudinal nature of the data allows us to follow firms' use (and adoption) of UFB over the sample period (2010-2016), as well as observing (time-varying) firm and worker characteristics and outcomes.[5]

The data on the firm's UFB status is obtained from the ICT module of the Stats NZ Business Operations Survey (BOS). The BOS is an annual survey of firms with at least six employees. The response rate for the survey is approximately 80% giving responses from approximately 6,000 firms per wave. The ICT module is run every second year of the survey, with our coverage extending from 2010 to 2016 (four waves).[6] Of the 9,336 firms covered across the four waves, 3,570 are observed only once. These firms are dropped from our panel analysis as we require at least two observations for each firm to model firms' transition in internet connection type. Of the remaining 5,766 firms, 2,061 are observed in all four waves, 1,818 in three waves and 1,887 in two waves.

The ICT module contains questions on whether the firm uses the internet; if so, whether it connects with broadband; and, if it does, the type of broadband connection. The specific question (question B12) in this latter respect is as follows:[7]

[4] We use Fabling & Maré's (2015) methodology for identifying part-time workers, job spells/tenure, and an estimate of full-time equivalent labour input from the linked employer-employee data.
[5] We use Fabling's (2011) longitudinal firm identifiers, which make use of employee tracking to repair links in Stats NZ firm identifiers.
[6] Changes to the ICT questions prior to 2010 prevent use of earlier waves of BOS data in the analysis.
[7] The exact wording here is taken from the 2010 BOS survey. For the eligible answers, the description omits local examples that the survey provides of these connection types that were designed to assist respondents answer correctly and so improve data quality.

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

- DSL including ADSL (provided over your copper telephone line)
- cable
- fibre-to-the-premise
- cellular technology
- wireless
- satellite, or
- don't know.

Any firm that answers "fibre-to-the-premise" is considered to have UFB whether or not they also use another form of internet connection such as cellular technology.

We also utilise a second question (question B13) that is included in the ICT module relating to the reasons behind the choice of internet type. The wording is as follows:

Mark all that apply. What were the considerations in choosing between types of internet connection?

- availability in business location
- startup costs
- ongoing connection and usage costs
- connection speed
- mobile access
- compatibility with this business's existing technology
- availability of technical support, or
- none of the above.

We match the ICT responses for each eligible BOS firm to data on firm size (measured by full-time employment in the year of each BOS response), and industry sector (47 industries).

A complication for our analysis arises for the case of multi-site firms, which comprise 31.4% of firm observations across the four surveys. With such firms, it is possible that the firm has UFB at some sites and not at others. We observe higher UFB penetration in multi-site relative to single plant firms: across the full sample, multi-site firms have a UFB penetration rate of 51.5% compared with 29.6% for single plant firms. In modelling firm adoption of UFB, we include the share of the firm's employment in each territorial authority to control for geographic differences in UFB availability across areas. Instruments relating to geographical proximity to schools reflect the minimum distance to a firms' physical locations. In our wage regressions, the inclusion of job (i.e. worker-firm) fixed effects account for geographical as well as other fixed characteristics.

Having defined our sample of firms, we then identify all workers employed at that firm for each month in each of our sample years. For a worker to be included in the sample, we must observe their sex and age (retaining only those aged 18 to 64 years), and we exclude workers in multiple jobs or who are in part-time employment. We do not include a worker's first or last month in a job so that the wage variable is not contaminated by part-month earnings. We only include workers who work at least six months for the firm during the relevant year so that each worker is attributed to only one firm in a specific year.[8]

Our estimation sample (used to estimate the effect of UFB adoption on wages) further restricts analysis to the 'predominant job' of each worker, being the firm that the worker is employed at for the longest period across our sample. Thus all our analysis is focused on specific worker-firm job matches. This focus enables us to abstract from workers who might switch between firms in order to take advantage of another firm's adoption of UFB (which would result in a source of endogeneity bias). The resulting sample comprises 1,324,400 observations of predominant full-time mid-spell jobs (i.e. of workers with a job in a specific firm) across the four years, comprising 810,100 observations for males and 514,300 for females.[9]

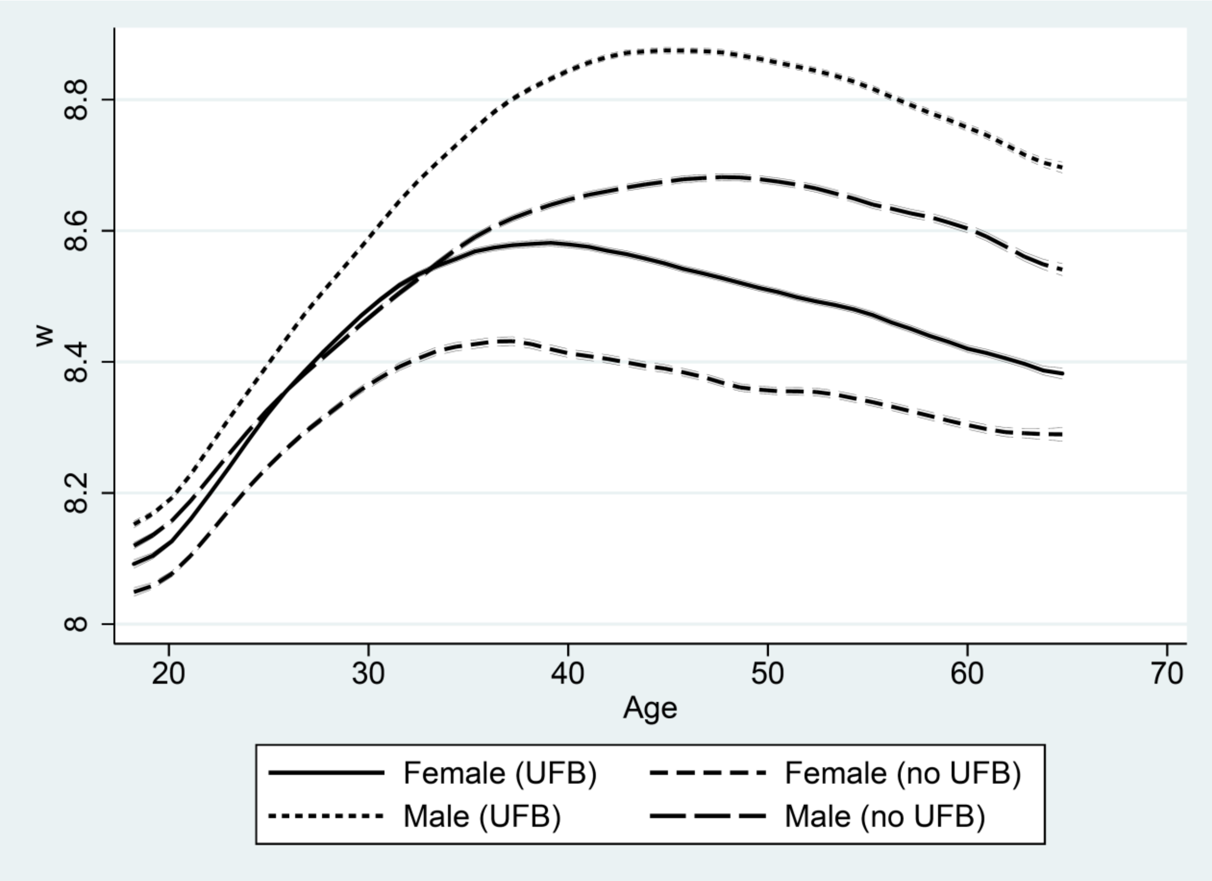
We calculate the real (consumer price index-deflated) wage for each worker, w, calculated as the worker's average monthly earnings in the sample year. For each worker in our sample, in addition to calculating their wage rate, we have information on their gender, age, tenure at the firm, and their highest qualifications.

Figure 1 shows the Epanechnikov kernel of (real) wages paid to females and males respectively according to whether the firm they work for has, or does not have, UFB. (The data in the figure is pooled across the four survey years.) Two features are apparent from Figure 1: First, males earn more than females; and second, employees (females and males) earn more in firms with UFB than in firms without UFB. Naturally, these kernel densities do not account for other relevant features that affect wages (e.g. sector, firm size or employee qualifications or age); such factors are controlled for in the econometric analysis that follows.

Worker qualifications (as a proxy for skills) may be relevant to wage outcomes if UFB is a complement or a substitute for some skills but not others. The qualifications data relating to workers are of two types. For both types of data, we treat qualifications as being fixed for each worker across the six-year sample period, since our qualifications data come exclusively from the 2013 Census.

[8] These restrictions remove 28% of full-time equivalent employment in the sample, with a greater proportion of women (who are more likely to be in part-time employment than men) lost than men (35% vs 23%).
[9] The number of observations is very similar across the four sample years; male observations vary between 195,200 and 213,900 per year; female observations vary between 124,000 and 135,400 per year.

Figure 1: Real wage (pooled across years) by gender and age, and by firm UFB status



The first type of qualifications data is information on the level of qualification (ranging from no school qualifications to PhD). We group this information in two ways. Our preferred grouping is a parsimonious disaggregation into 'unskilled' (no qualifications), 'semi-skilled' (qualifications below Bachelors degree level), and 'skilled' (Bachelors degree or above).[10] We also adopt a more detailed disaggregation into 10 groups based on qualification type; we use the latter grouping to check the robustness of our parsimonious specification. In each case, we include an additional 'unknown qualifications' category for those workers for whom we do not have qualifications information. Within our predominant job sample, females are, on average, slightly more qualified than males: 13.4% of workers are unskilled (11.7% for females, 14.5% for males), 50.3% are semi-skilled (51.2%, 49.7%), 19.3% are skilled (21.8%, 17.7%) while we are missing qualifications information for 17.0% (15.3%, 18.1%). Appendix Table 1 provides the proportions of the female and male samples with each level of qualification at the greater level of disaggregation.

[10] The terminology here – unskilled, semi-skilled, skilled – is adopted purely for convenience; we note that many in the 'semi-skilled' category do have significant workplace and non-workplace skills as do some in the 'unskilled' category.

The second type of qualifications data relates to the subject area in which qualifications are obtained. UFB may be complementary both to level of qualification and to STEM-related skills (i.e. to skills in science, technology, engineering and mathematics). Consequently, we differentiate each highest qualification above school level according to whether it was obtained in a STEM or a non-STEM subject.[11] We then analyse (through the wage impact) whether UFB is a complement or a substitute for certain worker types defined according to level of qualification and type of qualification (STEM or non-STEM). Appendix Table 2 provides the proportions of the female and male samples according to (aggregated) qualification level by subject of qualification, with eleven subject categories (plus an unknown category). Given the data available, STEM subjects are defined to include natural and physical sciences, information technology, and engineering and related technologies (subject categories 1-3 in the Census dataset). Within our predominant job sample, 15.3% of workers have a STEM qualification; notably, only 6.0% of females have a STEM qualification (at any level) compared with 21.4% of males. Thus, unlike the level of qualifications, the qualification subject varies substantially between females and males.

In Appendix Table 3 we document the shares of females and males by industry. It is apparent that, relative to males, females are more concentrated in the services sectors, particularly in health, education and professional services, the financial sector and in retail trade. As discussed in section 3, it is notable that some of these sectors (especially professional services and the financial sector) have high UFB penetration.

3 Firm UFB adoption

At the start of our sample period (2010), 99.2% of firms in our sample already had a broadband connection of some type. Thus our analysis both of the determinants and of the impacts of UFB adoption relates to a comparison of UFB versus other broadband connection types. This differentiates the analysis from the first generation of studies (including Akerman et al., 2015) that analysed the effects of broadband use versus dial-up (or zero) internet access.

Consistent with prior studies (e.g. Fabling and Grimes, 2016) our data shows that use of UFB is more prevalent in larger than smaller firms. Figure 2 shows the UFB penetration rate (i.e. proportion of firms with UFB) for the four years of our sample (2010, 2012, 2014 and 2016) according to firm size. Firm size is measured by the logarithm of total full-time equivalent (FTE) employment, denoted ln(L). Each year's curve represents the Epanechnikov kernel of UFB penetration with 95% confidence intervals shown. In addition to demonstrating a positive relationship of UFB penetration with firm size in each year, the figure also shows how UFB penetration has increased over time for all firm sizes. By 2016, approximately 85% of the largest

[11] Subject information is not collected in the Census for lower level qualifications.

firms had UFB whereas this figure was below 60% in 2010. For the smallest firms, only around 35% of firms had UFB in 2016 and only around 5% had UFB in 2010.

Figure 2: UFB penetration rate by firm size and year

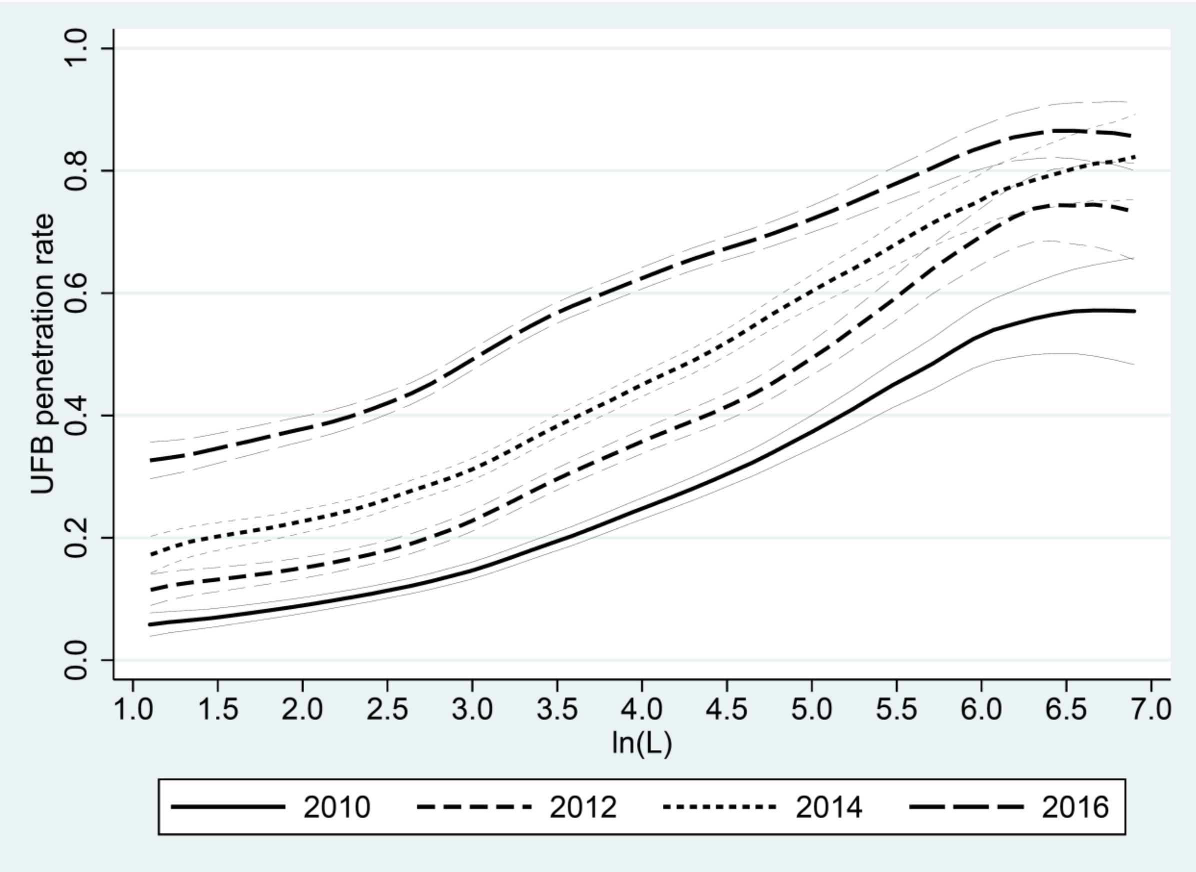
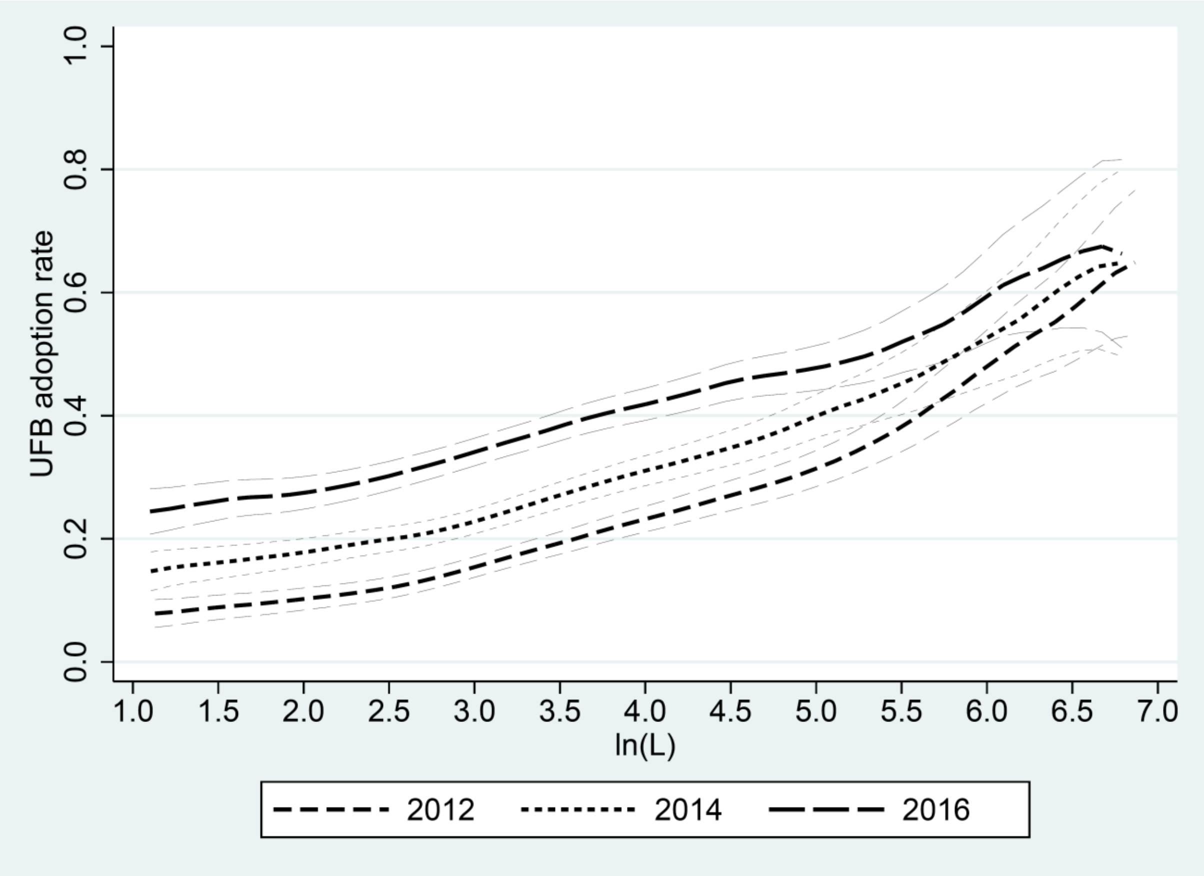


Figure 3 shows the UFB adoption rate by firm size over each two year period conditional on the firm not having UFB two years earlier.[12] Again the adoption rate increases in firm size for all three intervals; for all but the largest firms, the (conditional) adoption rate has increased over time. The varied experience in firms' UFB adoption both over time and across firms provides us with a strong degree of variation in our focal variable (firm UFB adoption).

[12] Hence adoption rates are shown only for 2012, 2014 and 2016.

Figure 3: UFB adoption rate by firm size and year (conditional on no prior UFB)



UFB penetration across firms varies by industry. Table 1 shows the proportion of firms in each industry sector with UFB for each of our four years. The proportion of firms with UFB rises across the four surveys in each sector. Nevertheless, the cross-sectional distribution of UFB remains diverse even in 2016 at which time the penetration varies from 17.0% (in the agriculture, forestry and fishing sector) to 79.3% (in financial and insurance services).

Table 2 presents the proportion of female and male (predominant job) workers within firms that have UFB for each year. One feature (other than the rising proportion of employees in firms with UFB over time) is that a higher percentage of females are within firms that have UFB than males, although the gap has closed over the sample period. This pattern likely reflects a greater early uptake of UFB in (relatively female-intensive) services firms within urban areas.

We use a probit model to investigate the determinants of UFB adoption by firms conditional on the firm not having UFB two years earlier. We initially pool all adoption years and then examine each year individually. Adoption is modelled as a function of firm size (log of FTE employment), the log of the firm's average (real) wage, a dummy variable if it has a single location (=0 if multi-site), the prior internet connection type (split between dial-up, DSL/ADSL, cable, cellular, wireless or satellite), stated considerations for choosing the connection type (availability of connection type, start-up costs, ongoing connection and usage costs, connection speed, mobile access, compatibility with existing technology, availability of technical support), plus log distance to nearest primary and secondary schools. The school distance variables reflect the policy choice of central government to prioritise fibre roll-out to schools (plus hospitals).

Table 1: Proportion of firms with UFB by sector and year

Sector	**2010**	**2012**	**2014**	**2016**
Agriculture, Forestry and Fishing	0.053	0.089	0.118	0.170
Mining	0.190	0.286	0.381	0.500
Manufacturing	0.161	0.237	0.341	0.515
Electricity, Gas, Water and Waste Services	0.167	0.240	0.346	0.433
Construction	0.114	0.171	0.309	0.527
Wholesale Trade	0.273	0.442	0.549	0.671
Retail Trade and Accommodation	0.127	0.178	0.262	0.421
Transport, Postal and Warehousing	0.259	0.367	0.400	0.573
Information Media and Telecommunications	0.373	0.483	0.673	0.709
Financial and Insurance Services	0.409	0.563	0.613	0.793
Rental, Hiring and Real Estate Services	0.291	0.359	0.474	0.674
Professional, Scientific, Technical, Administrative and Support Services	0.280	0.444	0.558	0.717
Education and Training	0.145	0.286	0.339	0.557
Health Care and Social Assistance	0.187	0.271	0.316	0.496
Arts, Recreation and Other Services	0.182	0.225	0.320	0.427
Agriculture, Forestry and Fishing	0.207	0.303	0.391	0.547

Table 2: Percentage of workers in firms with UFB (predominant job sample)

	Female	**Male**	**Total**
2010	56.6	50.6	52.9
2012	67.3	64.2	65.4
2014	72.8	71.1	71.8
2016	81.3	78.9	79.9
All years	69.5	66.3	67.5

Industry dummies (47 industries) and territorial authority employment shares are included in all four equations, and year dummies are included in the pooled estimate.

Estimated marginal effects from the probit models are presented in Table 3. All variables listed in the table are from two years prior other than the stated considerations for choosing the internet type which are current to match the adoption decision. The results show that firm size is an important determinant of adoption throughout the sample period (as shown in Figure 3), while higher wage firms (within industries) were more likely to be early adopters. Firms that already had access to cable and cellular internet connections were more likely to adopt UFB, consistent with firm IT capability being a determinant of UFB adoption. Firms that listed connection speed as a determinant had an increased likelihood of adopting UFB indicating a technology-related or market-related reason for adoption.

From the supply side, distance to nearest secondary school is shown to be an important adoption determinant throughout the sample. Given the existing location of firms, this distance-to-school variable is considered to be an exogenous factor that proxies for availability of a fibre connection and hence as an exogenous determinant of firm UFB adoption. In addition, there is no reason to believe that the distance to a school influences firm performance (or employee wages). It is therefore a suitable instrument for UFB adoption. We also treat the desire for connection speed as exogenous to the firm's adoption choice since it is likely to relate to the firm's existing technology and market type, and so precedes the adoption decision.

Table 3: Marginal effects probit model of firm UFB adoption given no UFB two years' prior

	All years	2012	2014	2016
Total employment (log)	0.286***	0.327***	0.309***	0.280***
	[0.020]	[0.035]	[0.035]	[0.037]
Average wage (log)	0.285***	0.432***	0.254**	0.177
	[0.067]	[0.123]	[0.121]	[0.113]
Single business location	-0.135***	-0.308***	-0.035	-0.14
Connection type	[0.047]	[0.086]	[0.083]	[0.086]
Dial-up	0.034	0.045	0.068	-0.006
	[0.059]	[0.103]	[0.112]	[0.102]
DSL/ADSL	-0.073	-0.099	-0.123	0.028
	[0.059]	[0.112]	[0.100]	[0.100]
Cable	0.261***	0.276*	0.199	0.242*
	[0.084]	[0.148]	[0.147]	[0.147]
Cellular	0.133***	0.027	0.237***	0.179***
	[0.038]	[0.073]	[0.066]	[0.067]
Wireless	-0.025	0.138*	0.001	-0.138*
	[0.043]	[0.083]	[0.076]	[0.075]
Satellite	0.031	-0.025	0.187	-0.119
Considerations in choosing (current period)	[0.106]	[0.218]	[0.166]	[0.199]
Availability	-0.059	-0.153**	-0.087	0.087
	[0.042]	[0.075]	[0.075]	[0.075]
Startup costs	-0.176***	-0.157*	-0.215***	-0.178**
	[0.045]	[0.083]	[0.077]	[0.086]
Ongoing connection & usage costs	-0.004	-0.067	-0.02	0.024
	[0.041]	[0.079]	[0.072]	[0.073]
Connection speed	0.746***	0.613***	0.760***	0.944***
	[0.040]	[0.077]	[0.073]	[0.072]
Mobile access	-0.065	-0.099	0.011	-0.101
	[0.047]	[0.087]	[0.081]	[0.084]
Compatibility with existing technology	-0.049	-0.056	-0.075	-0.135*
	[0.042]	[0.078]	[0.074]	[0.075]
Availability of tech support	-0.014	0.005	0.034	-0.047
Distance to nearest school	[0.048]	[0.085]	[0.084]	[0.090]
Distance to nearest primary school (log)	-0.004	-0.011	-0.007	0.016
	[0.011]	[0.019]	[0.017]	[0.019]
Distance to nearest secondary school (log)	-0.052***	-0.050**	-0.067***	-0.061**
	[0.014]	[0.023]	[0.024]	[0.027]
N	7371	2529	2478	2253
Pseudo-R^2	0.214	0.248	0.226	0.247
Year dummies	Y	N	N	N
Industry dummies	Y	Y	Y	Y
TA employment shares	Y	Y	Y	Y

Notes: Dependent variable is a dummy variable =1 if the firm adopts UFB (=0 otherwise). Robust standard errors, clustered on firms (*p<0.1, **p<0.05, ***p<0.01).

4 Methodology and results

We are primarily interested in how wages of different worker types react when a firm adopts UFB. If UFB adds to firm productivity, and if the effect is neutral across worker types, we would expect an equal wage premium to be paid to employees following adoption. If, however, UFB is complementary to only some types of worker input, we expect the premia to be limited to these workers. One reason to anticipate complementarities might be that people with certain skills (e.g. in STEM-related areas) can leverage the new faster internet speeds for the firm's benefit more so than those with other skills. A second reason that may underpin complementarities relates to the finding of Fabling and Grimes (2016) that firms benefit from UFB only if they also change their internal management practices in order to leverage the new technology. This factor may lead to skilled employees (including non-STEM employees) benefitting if they are in management positions that are tasked with delivering benefits to the firm from a new UFB connection. Conversely, if UFB is a substitute for some worker types, then these types of worker may receive a wage reduction (or slower wage growth) upon adoption.

As indicated in section 3, firm UFB adoption in part reflects existing firm attributes and in part reflects UFB availability as fibre is rolled out geographically. The roll-out in relation to proximity to schools provides one source of exogenous variation to model effects of UFB adoption. We estimate our base specification [listed as specification (i) below] both without instrumenting for UFB adoption and with an instrumental variables (IV) approach in which the dummy variable for the firm having UFB is instrumented. We have insufficient (strong) instruments to use an IV approach for our more disaggregated regressions.

All our estimates are derived from panel regressions with job (i.e. worker-firm) fixed effects. Our sample is deliberately limited to workers in their predominant employment (i.e. the firm for which they worked longest over the sample period). For instance, if we observe a worker with Firm A for 4 years and then with Firm B for 2 years, we only include that worker for the 4 year component of the sample for which they were at Firm A. This sample restriction enables us to control for any fixed aspect of the job (i.e. of that worker at that firm) through the inclusion of a fixed effect (FE) for each (worker-firm) job. This sample restriction and the inclusion of job fixed effects avoids one potential source of endogeneity that would be caused by workers switching to firms that adopt UFB. Accordingly, our identification comes from incumbent workers that remain employed within firms that switch into (or out of) UFB during the sample period. The instrumental variables estimates for our base specification further control for potential endogeneity of the firm's decision to switch to UFB.

The fixed effects equation that we estimate is specified as follows:

$$\ln(W_{ijt}) = \alpha + \sum_k \beta_k Q_{ik} UFB_{jt} + \gamma X_{it} + \delta Y_{jt} + \theta Z_{jst} + \mu_{ij} + \varepsilon_{ijt} \quad (1)$$

where:

W_{ijt} is real (CPI-adjusted) wage of worker *i* in firm *j* at time *t*,

Q_{ik} is a vector of dummy variables for quality type (k = 1, …, K) of worker *i*,

UFB_{jt} is a dummy variable = 1 if firm *j* has UFB at time t (=0 otherwise),

X_{it} is a vector of characteristics for worker *i* at time *t*,

Y_{jt} is a vector of characteristics for firm *j* at time *t*,

Z_{jst} is a vector of sector (industry)-year dummies where firm *j* is in sector *s*,

μ_{ij} is a vector of job (i.e. worker *i* in firm *j*) fixed effects,

ε_{ijt} is the residual term, and

α, β_k, γ, δ, and θ are (conformable vectors of) coefficients.

Worker characteristics comprise a quartic polynomial in worker age, plus the length of tenure for that worker at that firm (with a maximum category of 10 plus years' tenure). Firm characteristics are proxied by firm size (log of firm FTE employment) and implicitly also by the sector-year dummies where we have 47 industries.

Our instrumental variables specification instruments UFB_{jt} with two instruments: log distance from nearest school, and log distance from school interacted with a dummy variable indicating whether connection speed was stated as a consideration for the firm's internet connection type. The latter instrument is included to distinguish between firms that have access to fibre locally but do – or do not – require an ultra-fast broadband connection. We test the suitability of our instruments using the Kleiberger-Paap statistics for under-identification and for weak identification, together with the Hansen J over-identification test.

The β coefficients are our parameters of interest. For both estimation methods, we test four different specifications: (i) no variation by worker type (so the $\sum_k \beta_k Q_{ik} UFB_{jt}$ terms are replaced simply by βUFB_{jt}); (ii) Q_{ik} broken into 3 qualification levels (no qualifications, below-Bachelors level qualifications, and Bachelors and above) plus an unknown qualifications category; (iii) a more detailed version in which Q_{ik} is broken into 10 qualification levels (plus the unknown qualifications category); and (iv) the more parsimonious definitions of Q_{ik} in which post-school qualifications are split between STEM and non-STEM subjects. Specification (iii) is included principally as a robustness check to help judge the suitability of our preferred (unskilled, semi-skilled, skilled) qualifications split. Specification (iv) is included to test whether the impact of UFB adoption has different effects for workers with STEM skills as opposed to those without.

Table 4 presents the FE and IV-FE estimates for specification (i) for females and males respectively. We split all our samples by gender since the effects differ sharply between males and females.

Table 4: Wage impacts of UFB adoption, specification (i), FE and IV-FE estimates

	Female		Male	
	FE	**IV-FE**	**FE**	**IV-FE**
UFB	-0.003	-0.004	0.002	0.033*
	[0.002]	[0.016]	[0.002]	[0.018]
Controls	Y	Y	Y	Y
Job FEs	Y	Y	Y	Y
N	514,300	514,300	810,100	810,100
R^2	0.309	0.309	0.348	0.348
KP U-id		34.515		27.947
(p-value)		(0.000)		(0.000)
KP W-id		18.036		14.715
J O-id		0.436		0.254
(p-value)		(0.509)		(0.614)

Notes: FE are fixed effects estimates; IV-FE are instrumental variables estimates with fixed effects. UFB is a dummy variable =1 if worker is in a firm with UFB (=0 otherwise). Robust standard errors, clustered on firms (*p<0.1, **p<0.05, ***p<0.01). R^2 is R^2-within. Controls comprise industry-year dummies, a quartic polynomial of worker age, worker's tenure at firm, and firm size (log FTE employment). Instruments are log distance to nearest school and log distance interacted with connection speed stated as a reason for UFB choice. KP U-id is the Kleiberger-Paap test for underidentification (p-value in brackets); KP W-id is the Kleiberger-Paap test for weak instruments; J O-id is the Hansen J overidentification test (p-value in brackets).

The specification (i) estimates indicate that when we make no allowance for worker qualifications, we find no wage benefit for females as a group as a result of UFB adoption. There is some evidence (at the 10% level of significance) in the instrumented estimates that males as a group benefit from UFB adoption, although this effect is not apparent in the FE estimates.

Recall that these estimates are for our sample of incumbent workers. One potential selection effect could arise if adoption of UFB caused incumbent workers to leave the firm in which case they would not be observed following UFB adoption. To consider the relevance of this issue, we have estimated a supplementary equation at the firm level for the firm's log FTE employment as a function of UFB. The results indicate that adopting firms actually increase employment (by almost three percent) relative to non-adopters,[13] so employment reduction following UFB adoption does not appear to be a complicating factor for our wage analysis of incumbent workers.[14]

[13] The employment equation also includes firm fixed effects, year dummies and territorial authority employment shares. The coefficient on UFB is 0.028 (with standard error 0.006); R^2 = 0.085.
[14] Note that newly hired workers are not included in our wage equation sample since they are not incumbent workers.

When we include qualification levels in the wage equation [specification (ii), shown in Table 5] we find a richer picture. The estimates indicate that, following UFB adoption, unskilled and semi-skilled females plus unskilled males experience a small wage decrease while high skilled males experience a wage increase.

Table 5: Wage impacts of UFB adoption, specification (ii), FE estimates

UFB interacted with dummy variable for:	**Female**	**Male**
Unskilled worker	-0.007***	-0.004*
	[0.003]	[0.003]
Semi-skilled worker	-0.004*	0.001
	[0.002]	[0.002]
Skilled worker	0.002	0.011***
	[0.003]	[0.003]
Unknown skills	-0.004	-0.002
	[0.003]	[0.002]
Controls	Y	Y
Job FEs	Y	Y
N	514,300	810,100
R^2	0.309	0.348

Notes: Worker skills are as defined in section 2. See Table 4 for further notes.

Specification (iii) (Table 6) explores these results further using more detailed definitions of qualification levels, with qualitatively similar results. The estimates again show little benefit for females from UFB adoption with the possible exception of those with a Masters degree. Masters level graduates comprise 2.3% of the female workforce, so these gains are concentrated in a small proportion of female workers.

For males, the positive effect of UFB adoption on workers' wages is shown to be more widespread. Our estimates indicate that male workers with at least Level 5 Diploma/Certificate qualifications (excluding those with PhDs who comprise just 0.3% of the male sample) experience significant wage gains, with the gains greatest for those with Masters degrees. Level 5 qualifications (at which these wage benefits begin) include those with below-degree diplomas and certificates; 25.2% of males fall within the Level 5 to Masters degree qualification categories, so the gains accrue to a much larger proportion of males than females.

Another feature of the specification (iii) results is that the estimates confirm small wage losses for males who have no qualifications and for females with up to and including Level 4 Certificate qualifications (i.e. lower level certificate qualifications) upon firm UFB adoption. The No Qualification group comprises 14.5% of males, whereas 54% of females have up to and including Level 4 qualifications, confirming a pattern of female disadvantage relative to males following UFB adoption.

Table 6: Wage impacts of UFB adoption, specification (iii), FE estimates

UFB interacted with dummy variable for:	**Female**	**Male**
No qualification	-0.007***	-0.004*
	[0.003]	[0.003]
No post-secondary school (unknown sec. level)	-0.003	0.008
	[0.008]	[0.007]
Level 1-3 certificate	-0.004*	0.000
	[0.002]	[0.002]
Post-sec, unknown level	-0.002	0.003
	[0.004]	[0.003]
Level 4 certificate	-0.008**	0.000
	[0.003]	[0.002]
Level 5/6 diploma/certificate	-0.001	0.008**
	[0.003]	[0.003]
Bachelor Degree, Level 7 Grad Diploma/Certificate	0.000	0.009***
	[0.003]	[0.003]
Postgrad Diploma/Certificate, Bachelor Honours	0.008	0.009**
	[0.006]	[0.005]
Masters degree	0.010*	0.018***
	[0.006]	[0.005]
Doctorate degree	-0.008	0.019
	[0.019]	[0.012]
Highest qualification missing	-0.004	-0.002
	[0.003]	[0.002]
Controls	Y	Y
Job FEs	Y	Y
N	514,300	810,100
$\mathbf{R^2}$	0.309	0.348

Notes: See Table 4.

Table 7 presents the estimates of specification (iv) in which we analyse the complementarity of UFB with STEM skills. We retain each of unskilled and unknown qualification groups as single groups (given that we have no qualification subject information for these groups) and split high-skilled qualifications into STEM and other. We split the semi-skilled group into STEM, other and unknown.

Table 7: Wage impacts of UFB adoption, specification (iv), FE estimates

UFB interacted with dummy variable for qualifications by STEM	**Female**	**Male**
Unskilled worker	-0.007***	-0.004*
	[0.003]	[0.003]
Semi-skilled worker x $STEM^{unknown}$	-0.002	0.001
	[0.002]	[0.002]
Semi-skilled worker x $STEM^{yes}$	0.000	0.006*
	[0.005]	[0.003]
Semi-skilled worker x $STEM^{no}$	-0.005*	-0.003
	[0.003]	[0.002]
Skilled worker x $STEM^{yes}$	0.001	0.012***
	[0.005]	[0.003]
Skilled worker x $STEM^{no}$	0.003	0.010***
	[0.003]	[0.004]
Unknown skills	-0.006**	-0.001
	[0.003]	[0.002]
Controls	Y	Y
Job FEs	Y	Y
N	514,300	810,100
R^2	0.309	0.348

Notes: Worker skills are as defined in section 2. $STEM^{yes}$ is a dummy variable for a worker with a STEM qualification, $STEM^{no}$ is a dummy variable for a worker with a non-STEM qualification, $STEM^{unknown}$ is a dummy variable for a worker with an unknown qualification subject. See Table 4 for further notes.

The estimates indicate that females with no qualifications and semi-skilled females without STEM qualifications both experience a wage reduction following firm UFB adoption (as do those with unknown qualifications). There is no evidence that STEM-qualified females benefit from firm UFB adoption. For males, we again see a wage reduction for those who are unskilled. Both semi-skilled and skilled males with STEM qualifications benefit from UFB adoption as do skilled males without STEM.

Overall, there is a clear pattern as to who benefits and who loses, both in absolute and relative terms, following firms' adoption of UFB. The major beneficiaries are males with STEM qualifications, plus males (and possibly Masters level females) with university level (non-STEM) qualifications. Other groups either experience no wage benefit from UFB adoption or experience a small wage decrease relative to similar workers in firms that do not adopt UFB. The implication of these findings is that UFB is a complement to STEM skills and to more general non-STEM skills of highly qualified people. Furthermore, the estimates imply that UFB is either neutral with respect to lower-skilled non-STEM workers or is a substitute for those workers.

5 Conclusions

New Zealand's central government initiated a large roll-out of fibre starting in 2011. Our statistics show one result of this large-scale programme was that firms' use of UFB rose markedly, with the UFB penetration rate rising from 21% in 2010 to 55% in 2016. Large firms tended to be early UFB adopters as did firms in the financial and media and telecommunications sectors. Firms for which internet speed was considered important are shown to have adopted early and to have had a higher UFB penetration rate throughout the sample period. We demonstrate that a geographic aspect of the roll-out – the targeting of the fibre programme to schools – had an effect on firm adoption, with distance to the nearest (secondary) school having strong predictive power for firm UFB adoption. The combination of this exogenous geographic aspect together with the firm's existing characteristics, exhibited through its need for fast broadband, provides us with reasonable instruments for fibre adoption (which pass standard tests for instrument reliability). However, we do not have sufficiently strong instruments to use an IV approach for our (skill-based) disaggregated specifications.

Our analysis of the effects of UFB adoption on wages paid to individual employees uses fixed effects models in which we focus on the effect of a firm's transition to UFB on its incumbent workers' wage outcomes. Our identification strategy excludes workers switching jobs to increase their wages at another firm that does adopt UFB (which would have been a potential source of endogeneity) and we include fixed effects for every worker-firm (i.e. job) match. These approaches are chosen to minimise the risks of biases due to endogeneity of fibre choice by the firm. We note that few workers will be involved in the decision of the firm to adopt UFB, so it is reasonable to consider that the firm's adoption of UFB is exogenous with respect to (most) individual workers.

We find that UFB adoption by firms leads to some wage increases for incumbent workers, but these effects differ by gender, qualification level and skill type. Degree qualified men (and possibly Masters degree qualified women) benefit from UFB adoption as do men with STEM qualifications at post-school levels (including degree level). We find no such wage benefits for STEM qualified women. Overall, it appears that UFB is a complement to (at least male) workers with skills reflected either through STEM or through degree qualifications. The largest wage gains lie between 1% and 2%, which is a similar order of gain as found for productivity improvements in schools that adopt UFB (Grimes and Townsend, 2018), but smaller than the productivity effects found by Fabling & Grimes (2016) for firms that adopted UFB and also made complementary management investments.

At the other end of the qualifications scale, we see that men with no qualifications and women with no qualifications or with lower level qualifications appear to suffer a slight wage decrease of around 0.5% relative to workers in other firms following their employer's adoption of UFB. The implication of these results is that adoption of UFB enables firms to substitute for lower skilled workers, e.g. through greater use of out-sourcing for roles that utilise lower skilled workers.

The magnitude and direction of these results suggest that this new technology is acting – like some others – to magnify wage gaps between skilled (especially STEM-skilled) employees and other workers. The presence of skill-biased technical change has been documented in several studies in other applications, and it appears to be present also with UFB. The underpinnings for skill bias in this case may be that workers with STEM skills and workers who are in management positions tasked with reorienting work practices are best placed to leverage a new UFB connection to the benefit of the firm.

The results by qualification level mirror the qualification-related effects of adoption for early broadband types (Akerman et al., 2015). Our STEM-related results extend the scope of prior analyses to qualification subject. Furthermore, we provide extensions by examining the skill complementarities of UFB versus earlier (much slower) forms of broadband and through the use of longitudinal rather than cross-sectional data.

While our skill-related results are not altogether unexpected, what is more puzzling is why these effects differ between men and women. It is possible that our qualifications categories (e.g. STEM versus non-STEM) are too coarse to pick up the exact skills that are complementary to UFB. Other explanations could include that attitudes to risk (e.g. towards utilising new technologies) differ by gender or some form of discrimination in the labour market may be present that rewards men more than women when the firm adopts a new technology. For instance, it is conceivable that the task of leveraging new technologies for the benefit of the firm is allocated more to male than to female managers. Alternatively, men may be more likely than women to be rewarded through performance pay schemes when firm productivity rises (Fabling et al., 2012).

Overall, our study adds to the understanding of the impacts of the new UFB technology on firm performance as reflected in its wages paid. It also adds to the understanding of the differential effects of this technology adoption on wage gaps, both according to skill and gender. The skill result confirms that skill-biased technical change operates in this aspect of technical progress as it does in some others. However the puzzle remains to be answered as to why (some) men benefit more in terms of their wages than do (most) women when their employer adopts ultra-fast broadband. This aspect of our results could be a fruitful field for further study both for analysts of the impacts of technological change and for researchers examining the gender wage gap.

References

Ahlfeldt, G., P. Koutroumpis, and T. Valletti (2017). Speed 2.0: Evaluating access to universal digital highways, Journal of the European Economic Association 15 (3), 586-625.

Akerman, A., I. Gaarder, and M. Mogstad (2015). The skill complementarity of broadband internet. The Quarterly Journal of Economics 130(4), 1781–1824.

Autor, D., F. Levy, and R. Murnane (2003). The skill content of recent technological change: An empirical exploration. Quarterly Journal of Economics 118(4), 1279–1333.

Bertschek, I., W. Briglauer, K. Hüschelrath, B. Kauf, and T. Niebel. (2015). The economic impacts of broadband internet: A survey (2015). Review of Network Economics 14(4), 201–227.

Blau, F., and L. Kahn (2017). The gender wage gap: Extent, trends, and explanations. Journal of Economic Literature 55(3), 789-865.

European Commission (2016). A Digital Agenda for Europe. Brussels: European Commission.

Fabling, R. (2011). Keeping it together: Tracking firms on New Zealand's longitudinal business database, Working Paper 11-01, Wellington: Motu Economic and Public Policy Research.

Fabling, R., and A. Grimes (2016). Picking up speed: Does ultrafast broadband increase firm productivity? Working Paper 16-22, Wellington: Motu Economic and Public Policy Research.

Fabling, R., A. Grimes and D. Maré (2012). Performance pay systems and the gender wage gap. Working Paper 12-13, Wellington: Motu Economic and Public Policy Research.

Fabling, R. and D. Maré (2015). Addressing the absence of hours information in linked employer-employee data, Working Paper 15-17, Wellington: Motu Economic and Public Policy Research.

Fabling, R. and L. Sanderson (2016). A rough guide to New Zealand's Longitudinal Business Database (2nd edition). Working Paper 16-03, Wellington: Motu Economic and Public Policy Research.

Goldfarb, A. and C. Tucker (2019). Digital economics. Journal of Economic Literature 57(1), 3-43.

Goos, M. (2018). The impact of technological progress on labour markets: Policy challenges. Oxford Review of Economic Policy 34(3), 362–375.

Graetz, G and G. Michaels (2018). Robots at work. The Review of Economics and Statistics 100(5), 753-768.

Grimes, A., C. Ren, and P. Stevens (2012). The need for speed: Impacts of internet connectivity on firm productivity. Journal of Productivity Analysis 37(2), 187–201.

Grimes, A., and W. Townsend (2018). The effect of fibre broadband on student learning. Information Economics and Policy 44, 8-15.

Mirza, F., and F. Beltrán. (2014). Consumer resistance factors for the adoption of FTTH ultra-fast broadband in New Zealand. Journal of Information Policy 4, 128–43.

New Zealand Government. (2011). Statement to the Commerce Commission concerning incentives for businesses to invest in ultra-fast broadband infrastructure. New Zealand Gazette 155, Wellington: NZ Government.

Sin, I., S. Stillman, and R. Fabling. (2017). What drives the gender wage gap? Examining the roles of sorting, productivity differences, and discrimination. Motu Working Paper 17-15, Wellington: Motu Economic and Public Policy Research.

Appendix tables

Appendix Table 1: Percentage of workers according to disaggregated qualification levels

Qualification level	Female	Male	Total
0 No qualification	11.7	14.5	13.4
1 No post-secondary school (unknown secondary level)	0.7	0.6	0.6
2 Level 1-3 certificate	35.6	27.3	30.5
3 Post-secondary (unknown level)	1.8	1.9	1.9
4 Level 4 certificate	4.6	12.1	9.2
5 Level 5/6 diploma/certificate	8.4	7.8	8.1
6 Bachelor Degree, Level 7 Graduate Diploma/Certificate	16.1	12.5	13.9
7 Postgraduate Diploma/Certificate, Bachelor Honours	3.1	2.4	2.7
8 Masters degree	2.3	2.5	2.4
9 Doctorate degree	0.2	0.3	0.3
Unknown	15.3	18.1	17.0

Appendix Table 2: Percentage of workers according to subject of qualification

	Female	Male	Total
No Qualification (‘unskilled’)	11.7	14.5	13.4
No Post-School Qualification (‘semi-skilled’)	29.7	22.5	25.3
Below Degree Qualification (‘semi-skilled’)			
1 Natural and Physical Sciences	0.5	0.3	0.4
2 Information Technology	0.8	1.0	0.9
3 Engineering and Related Technologies	0.8	12.9	8.2
4 Architecture and Building	0.2	2.5	1.6
5 Agriculture, Environmental and Related Studies	0.4	1.1	0.8
6 Health	2.7	0.3	1.2
7 Education	1.1	0.2	0.5
8 Management and Commerce	6.8	2.7	4.3
9 Society and Culture	1.6	0.6	1.0
10 Creative Arts	1.0	0.7	0.8
11 Food, Hospitality and Personal Services	1.5	1.3	1.4
Highest qualification or subject missing	4.1	3.6	3.8
Degree Qualification (‘skilled’)			
1 Natural and Physical Sciences	2.0	1.9	1.9
2 Information Technology	0.8	1.8	1.4
3 Engineering and Related Technologies	1.1	3.5	2.6
4 Architecture and Building	0.3	0.4	0.3
5 Agriculture, Environmental and Related Studies	0.3	0.5	0.4
6 Health	2.3	0.4	1.1
7 Education	1.8	0.2	0.8
8 Management and Commerce	6.9	5.6	6.1
9 Society and Culture	4.3	2.3	3.1
10 Creative Arts	1.5	0.7	1.0
11 Food, Hospitality and Personal Services	0.0	0.0	0.0
Highest qualification or subject missing	0.6	0.5	0.5
Highest qualification missing	15.3	18.1	17.0

Appendix Table 3: Percentage of workers according to industry sector

Industry sector	**Female**	**Male**	**Total**
Agriculture, Forestry and Fishing	1.4	2.8	2.3
Mining	0.4	1.3	0.9
Manufacturing	18.3	31.5	26.4
Electricity, Gas, Water and Waste Services	1.4	1.8	1.7
Construction	1.6	8.7	5.9
Wholesale Trade	6.8	9.3	8.4
Retail Trade and Accommodation	9.1	5.8	7.1
Transport, Postal and Warehousing	7.3	9.9	8.9
Information Media and Telecommunications	4.9	4.2	4.5
Financial and Insurance Services	14.7	6.5	9.7
Rental, Hiring and Real Estate Services	1.7	1.2	1.4
Professional, Scientific, Technical, Administrative and Support Services	15.5	12.8	13.8
Education and Training	3.6	0.9	1.9
Health Care and Social Assistance	11.9	1.4	5.5
Arts, Recreation and Other Services	1.4	1.9	1.7

Recent Motu Working Papers

All papers in the Motu Working Paper Series are available on our website https://motu.nz, or by contacting us on info@motu.org.nz or +64 4 939 4250.

19-22 Maré, David C. 2019. “Occupational drift in New Zealand: 1976-2018.”

19-21 Sin, Isabelle and Bronwyn Bruce-Brand. 2019. “Is the pay of medical specialists in New Zealand gender biased?”

19-20 Maré, David C and Jacques Poot. 2019. “Commuting to diversity.”

19-19 Noy, Ilan, David Fleming, Jacob Pastor-Paz and Sally Owen. 2019. “EQC and weather events in New Zealand.”

19-18 Riggs, Lynn, Isabelle Sin and Dean Hyslop. 2019. “Measuring the ‘gig’ economy: challenges and options.”

19-17 Grimes, Arthur and Dominic White. 2019. “Digital inclusion and wellbeing in New Zealand.”

19-16 Maré, David C and Richard Fabling. 2019. “Competition and productivity: Do commonly used metrics suggest a relationship?”

19-15 Hall, Viv B and C John McDermott. 2019. “Changes in New Zealand’s Business Insolvency Rates after the Global Financial Crisis.”

19-14 Hyslop, Dean, Trinh Le, David C Maré and Steven Stillman. 2019. “Housing markets and migration – Evidence from New Zealand.”

19-13 Coleman, Andrew. 2019 “Liquidity, the government balance sheet, and the public sector discount rate.”

19-12 Winchester, Niven, Dominic White and Catherine Leining. 2019. “A community of practice for economic modelling of climate change mitigation in New Zealand.”

19-11 Fleming, David A., Suzi Kerr and Edmund Lou. 2019. “Cows, cash and climate: Low stocking rates, high-performing cows, emissions and profitability across New Zealand farms.”

19-10 Cortés-Acosta, Sandra, David A. Fleming, Loïc Henry, Edmund Lou, Sally Owen and Bruce Small. 2019. “Identifying barriers to adoption of “no-cost” greenhouse gas mitigation practices in pastoral systems.”

19-09 Kerr, Suzi, and Catherine Leining. 2019. ‘Paying for Mitigation: How New Zealand Can Contribute to Others’ Efforts.”

19-08 Kerr, Suzi, and Catherine Leining. 2019. “Uncertainty, Risk and Investment and the NZ ETS.”

19-07 Leining, Catherine and Suzi Kerr. 2019. ‘Managing Scarcity and Ambition in the NZ ETS.”

19-06 Grimes, Arthur, Kate Preston, David C Maré, Shaan Badenhorst and Stuart Donovan. 2019. “The Contrasting Importance of Quality of Life and Quality of Business for Domestic and International Migrants.”

19-05 Maré, David C and Jacques Poot. 2019. “Valuing Cultural Diversity.”

19-04 Kerr, Suzi, Steffen Lippert and Edmund Lou. 2019. “Financial Transfers and Climate Cooperation.”

19-03 Fabling, Richard and David C Maré. 2019. “Improved productivity measurement in New Zealand's Longitudinal Business Database.”

19-02 Sin, Isabelle and Judd Ormsby. 2019. “The settlement experience of Pacific migrants in New Zealand: Insights from LISNZ and the IDI”

19-01 Benjamin Davies and David C Maré. 2019. “Relatedness, Complexity and Local Growth.”

Motu