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The Empirical Link Between Fibre-to-the-Premises Deployment and Employment:

A Case Study in Canada

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I. Introduction

This study analyzes the empirical linkage between deployment of fibre-to-the-premises (FTTP) broadband and economic activity, as captured by employment effects. Prior work has assessed the economic effects of first generation broadband deployment, and has generally found significant effects; however, these studies have also been characterized by various limitations. In this paper, we use a proprietary deployment database from Bell Canada to study the impact of FTTP on Canadian employment. In contrast to first generation broadband, FTTP is not ubiquitously deployed—at least not yet. By 2013, 15 percent of Canadian homes were covered by FTTP.[1] By observing the effects of a new technology very much in the process of being rolled out, we can exploit a richer source of variation compared to prior studies of first generation deployment.

We construct a region-level balanced panel dataset spanning 2009 through 2014. During this critical timeframe, many of the regions studied began with little or no FTTP, and ended with substantial or even ubiquitous coverage.

To our knowledge, our study is the first to precisely observe deployment of a specific technology in a specific region at a specific point in time, and to identify the effect of deployment through variation over time within a given region, allowing us to control for many region-specific confounding factors. The results of the analysis point to a statistically and economically significant effect of deploying FTTP technology: Using a fixed effects regression, we estimate that fibre deployment to 100 percent of a region is associated with an increase in employment of approximately 2.9 percent.

Given that the majority of these regions already have existing broadband coverage, the positive employment impact is specific to FTTP deployment, and is over and above the employment benefits that arose from previous broadband deployment. In other words, even in regions which already have broadband, upgrading broadband infrastructure to FTTP is expected to result in an almost 3% increase in employment in that community. Based on the empirical linkage between FTTP deployment and employment, policymakers should exercise caution when considering regulations that reduce incentives to

1. *See* CRTC, Communications Monitoring Report 2014, Figure 5.1.5 (equal to 2 million homes divided by 13.3 million nationwide homes). As of 2013, there were approximately 540,000 FTTH connections in Canada, which had the fastest growth rate in North America. *See* RVA Market Research, *FTTH Progress In North America* (April 2013).

invest in FTTP deployment, such as mandatory unbundling.

II. The Empirical Literature on Broadband Employment Effects

One problem facing researchers studying first generation broadband such as DSL or cable modem service was that it was deployed in a fairly ubiquitous way (at least in both the United States and Canada), which makes teasing out the incremental effect of broadband on employment difficult to measure. In particular, the lack of a reliable benchmark (communities *not* served at all) limits cross-sectional analysis. Another limitation is that publicly available data sets tend to report only rough proxies for broadband deployment, which researchers have used to construct relatively coarse metrics (e.g., the number of broadband providers, or a simple count of the available technologies). These proxies gloss over important differences in speed or other dimensions of service quality, as well as the true extent of deployment and availability of each technology within a given geography.

Another complication in estimating the economic effects of broadband is the issue of endogeneity, which is of particular concern in any study relying on cross-sectional variation for identification. Internet service providers (ISPs) are not randomly choosing communities in which to invest billions of dollars to build out their networks; instead, they select communities that exhibit characteristics that are likely correlated with better economic health. Several studies have identified a statistical link between broadband and employment (or income), but did not attempt to correct for the endogeneity problem.

For example, Shideler, Badasyan and Taylor (2007) show that higher broadband coverage in a county in Kentucky contributes from 0.14 to 5.32 percent to total employment growth, depending on the industry being studied.[2] Crandall, Lehr and Litan (2007) estimate that for every one percentage point increase in broadband penetration in a state, employment increases by 0.2 to 0.3 percent per year.[3] To the extent that an ISP's decision to deploy broadband in a given geographic area is influenced by unobserved factors that also affect economic perfor-

2. David Shideler, Narine Badasyan, and Laura Taylor, The Economic Impact of Broadband Deployment in Kentucky, Federal Reserve Bank of St. Louis Regional Economic Development, 3(2), 88-118 (2007), *available at* https://research.stlouisfed.org/publications/red/2007/02/Shideler.pdf.
3. Robert Crandall, William Lehr and Robert Litan, The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data, 6 Issues in Economic Policy, Brookings (July 2007), *available at* http://www.brookings.edu/views/papers/crandall/200706litan.pdf.

mance in that area, the estimated coefficients from these models may be upwardly biased.

More recent studies have attempted to control for endogeneity using instrumental variables techniques, while continuing to rely on cross-sectional variation. For example, Kolko (2012) found that first-generation broadband deployment in the United States promoted employment growth in IT-intensive industries, but did not affect average wages and employment rates.[4] The author attempted to control for endogeneity by using the average slope of the local terrain as an instrument for broadband availability. Because this instrument is constant over time, the econometric model cannot measure the effect of broadband deployment within a given geographic area over time. Instead, the identification strategy hinges on the fact that broadband availability varies from one area to another, and the assumption that terrain slope has no direct effect on economic growth, apart from its effect on broadband availability.[5] Noting that "[s]everal possibilities arise as to why slope might affect economic activity outside of an indirect effect on broadband availability,"[6] the author introduces additional controls designed to mitigate such bias, while conceding that "[i]nstrumenting for broadband expansion with slope of terrain leans in the direction of a causal relationship, though not definitively."[7] Another important caveat is that broadband availability is measured using the FCC's count of broadband providers in a ZIP code; this is "an imperfect measure of availability,"[8] which "does not take into account either advertised bandwidth or realized speed, both of which can vary considerably across different locations."[9]

More recently, Ivus and Boland (2015) found that first-generation broadband coverage promoted employment and wage growth in service industries in rural regions, but did not produce a similar benefit in urban regions.[10] Similar to Kolko (2012), the authors' identification strategy is to use variation in elevation as in instrument designed to capture variation in the cost of broadband deployment. As before, the instrument is (by definition) invariant over time, and identification of any wage or employment effects hinges entirely on cross-sectional variation.

4. Jed Kolko, *Broadband and Local Growth*, 71(1) JOURNAL OF URBAN ECONOMICS 100-113 (2012).
5. *Id.* at 103.
6. *Id.*
7. *Id.* at 100.
8. *Id.* at 112.
9. *Id.*
10. Olena Ivus and Matthew Boland, The Employment and Wage Impact of Broadband Deployment in Canada, CANADIAN JOURNAL OF ECONOMICS (2015), *available at* http://works.bepress.com/cgi/viewcontent.cgi?article=1008&context=olena_ivus.

Ivus and Boland utilize Canada's National Broadband Coverage database, which provides indicator fields for the availability of DSL, cable, and fixed wireless, but not for fibre to the node or fibre to the home. The authors then design a broadband score for each community studied, with three being the maximum value achievable (if all three technologies were available in the community). The three technologies are treated as perfect substitutes in the analysis, with equal weights assigned to each technology.[11] Because first-generation broadband technologies are nearly ubiquitous in urban areas,[12] the lack of a significant finding in these areas could be attributable to the lack of variation in the deployment variable. In any event, the study is silent on the impact of fibre deployment.

In contrast to prior work, the proprietary FTTP deployment data used here allow us to pinpoint deployment of a specific technology in a specific region at a specific point in time, and to isolate the effect of deployment on economic observables while explicitly holding fixed region-specific factors that may have caused the area to have been selected for deployment in the first place. Specifically, we estimate a regression model that relates annual employment at the region level with the share of the region deployed with FTTP at a given point in time. Using standard panel-data methods, the model controls for region and annual fixed effects, as well as other variables that might influence employment. In contrast to prior work, this allows us to account for all factors that are common to a given region and invariant over time, as well as all factors that are common across regions but fluctuate from year to year. The identification strategy therefore hinges on observing sufficient within-region variation in deployment to measure any resulting impact on regional employment levels.

11. *Id.* at 13.
12. Whereas 99 and 98 percent of large and medium population centers in Canada, respectively, had access to at least one provider capable of delivering 10 Mbps down by 2013, only 33 percent of rural areas offered that same capability. *See* CRTC, Communications Monitoring Report 2014, Figure 5.3.17.

III. The Data Set

Bell Canada provided its FTTP deployment data at the municipality level for Bell Canada and Bell Aliant. For each observation, the data indicate the year of the FTTP launch, the number of homes passed with FTTP as of July 2014, and the total number of homes passed by Bell in the municipality. The earliest launch occurred in 2009, and 120 of the 351 municipalities had no FTTP coverage from Bell as of 2014, while 45 had 100 percent coverage of households passed by Bell. The household-weighted average coverage rate across all municipalities was 23.4 percent.

Official employment data in Canada is kept at the economic region level, level as opposed to the municipality.[13] To merge deployment data at the municipality into economic regions, each municipality was assigned to a CSN (Census Subdivision Name) in Statistics Canada's database, corresponding to an ERN (Economic Region Name).[14]

Annual real gross domestic product (GDP) is published at the province level.[15] Accordingly, each municipality in the FTTP deployment data was assigned to its corresponding Province.

The regression data set consists of a panel of 39 regions spanning six years (2009 – 2014), for a total of 234 observations. Summary statistics for the regression variables are shown in Table 1.

13. CANSIM Table 282-0122, *available at* http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=2820122; CANSIM 282-0126, *available at* http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=2820062.
14. Geographic Attribute File, *available at* http://www12.statcan.gc.ca/census-recensement/2011/geo/ref/att-eng.cfm. If a municipality could not be directly matched to a CSN, the closest geographic approximation (using Google Maps) was selected in its place.
15. CANSIM Table 379-0030, *available at* http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=3790030.

Data Set

Table 1
Summary Statistics

Variable	Source	Observations	Mean	Min	Max	Std. Dev
Employment (1,000s), Region	Statistics Canada	273	333	36	3,280	539
Fibre Deployment (%)	Bell, Bell Alliant, Statistics Canada	234	0.068	0	1	0.15
Real GDP (1,000,000s, 2007 $CAN), Province	Statistics Canada	234	269,343	4,273	600,574	213,184
Population (1,000s), Region	Statistics Canada	273	552	64	5,336	873

IV. Estimation Methodology and Results

Given that a panel of broadband deployment is available—that is, each region is observed repeatedly over time—a fixed effects approach is appropriate. Fixed effect regression models provide a straightforward and direct method of controlling for any and all unobserved factors specific to a region that remain invariant over time. The regression accomplishes this by, in effect, estimating a separate and unique constant term for each region. The general form of the fixed effects specification is as follows:

$$\ln(emp_{it}) = \beta_0 + \gamma_i + \alpha_t + \beta_1 F_{it} + \beta_2 \ln(GDP_{it}) + \beta_3 \ln(POP_{it}) + \varepsilon_{it} \quad (1.1)$$

Above, $\ln(emp_{it})$ denotes the natural log of employment in region i in year t. The coefficients γ_i represent the fixed effects specific to each of the 39 regions included in the analysis, while the coefficients α_t represent time fixed effects. The former account for all factors that are common to a given region and invariant over time; the latter account for all factors that are common across regions and vary from one year to the next. The remaining variables in equation (1.1) control for other factors that may also influence regional employment. Specifically, the model controls for fluctuations in local economic conditions using the real GDP for the province in which region i is located,[16] and also for shifts in regional population.

The key variable of interest in the regression model is F_{it}, which measures the extent of fibre deployment in region i in year t. We measure fibre deployment by estimating the share of households passed by fibre within a given region at a given point in time. Specifically, let S_k be the share of households passed by fibre deployment in city k as of 2014,[17] let BHH_k be the number of households passed by Bell in city k as of 2014, and let D_{kt} be an indicator equal to one if fibre has been deployed in city k at time t, and zero otherwise. Finally, let HH_k be the total number of households in the region as of 2011.[18] The extent of fibre deployment in region i can be estimated using the following ratio, which sums across all cities in a given region:

16. Gross Domestic Product statistics in Canada are not compiled at the region level.
17. We lack data on household fibre coverage for the other years in our sample. Nevertheless, the extent of coverage achieved by 2014 provides important information, because many of the cities in our data set received only modest deployment (e.g., less than five percent) by 2014. By taking this into account, we can distinguish between these areas and others where fibre deployment approached (or achieved) 100 percent penetration.
18. This is the most recent year for which region-level household statistics are available. We utilized private dwellings occupied by usual residents as of 2011.

$$(1.2) \quad F_{it} = \frac{\sum_{k=1}^{K} D_{kt} S_k BHH_k}{\sum_{k=1}^{K} HH_k}$$

The results of the fixed effects model are reported in Table 2. Our primary specification, reported in column (1), utilizes the formula in equation (1.2) above to estimate deployment. The specification in column (2) uses the same formula, but substitutes a different household metric (private dwellings, instead of private dwellings occupied by usual residents). Finally, the specification in column (3) calculates deployment based on the share of households passed within Bell's footprint (using BHH_k to compute the denominator in equation (1.2)). All specifications are semi-logarithmic, because the key independent variable of interest, F_{it}, enters in levels.

As seen above, the effect of fibre deployment is positive and highly statistically significant. In our primary specification, fibre deployment to 100 percent of a region is associated with an increase in employment of approximately 2.9 percent.[19] The control variables also have intuitive effects: As expected, an increase in population is associated with an increase in employment levels; an increase in real provincial GDP is also associated with greater employment. Finally, the model explains the vast majority of variation in the dependent variable, with an *R*-squared in excess of 99 percent.

19. These results are consistent with the analysis conducted in Hal J. Singer, *The Economic Impact of Fibre Deployment in Toronto* (January 2015) (prepared for Bell Canada) and Hal J. Singer, *Policy Brief: The Economic Impact of the CRTC's Decision to Unbundle FTTP Networks* (October 2015)(prepared for Bell Canada), which is that FTTP deployment has a positive impact on employment. Note that these results are likely conservative given: (1) the employment effects measured here are limited to the region in which the FTTP investment occurred, and (2) much of the FTTP investment occurred shortly before the last year (2014) in the regional employment data.

Table 2
Fixed Effects Regression Results

Dependent Variable	(1) Primary Model *ln*(Employment)	(2) Private Dwellings *ln*(Employment)	(2) Bell Footprint *ln*(Employment)
Fibre Deployment	0.029**	0.027*	0.0264**
	(0.038)	(0.052)	(0.003)
ln(Real Provincial GDP)	0.376*	0.368*	0.433**
	(0.015)	(0.018)	(0.004)
ln(Regional Population)	0.827***	0.825***	0.880***
	(0.000)	(0.000)	(0.000)
Observations	234	234	234
R-squared	99.96%	99.96%	99.96%

Notes: Fixed effects by region and year suppressed; *p*-values calculated from robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

V. Conclusion

Although prior studies attempting to assess the economic effects of broadband deployment have often found significant effects, they have also been characterized by various limitations. Earlier work relied upon cross-sectional variation without controlling for endogeneity. Later work has exploited instrumental variables techniques designed to surmount this problem, but has continued to rely entirely on cross-sectional variation, and on coarse proxies for broadband deployment.

To our knowledge, our study is the first to precisely observe deployment of a specific technology in a specific region at a specific point in time, and to identify the effect of deployment through variation over time within a given region, allowing us to control for many region-specific confounding factors. The results of the analysis point to a statistically and economically significant effect of deploying FTTP technology.

Given that the majority of these regions already have existing broadband coverage, the positive employment impact is specific to FTTP deployment, and is over and above the employment benefits that arose from previous broadband deployment. We conclude that fibre deployment to 100 percent of a region is associated with an increase in employment of approximately 2.9 percent. Based on the empirical linkage between FTTP deployment and employment, policymakers should exercise caution when considering regulations that reduce incentives to invest in FTTP deployment, such as mandatory unbundling.