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Economic Impact of FTTH Deployment in Toronto

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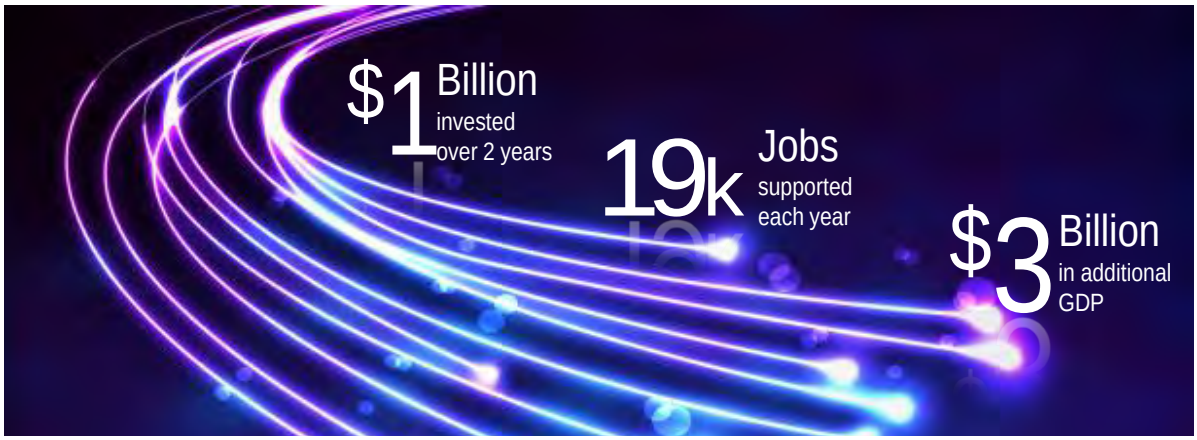

Summary

This Policy Brief quantifies the economic impact of a planned fibre-to-the-home (FTTH) deployment by Bell Canada in the City of Toronto. This FTTH project aims to deliver fibre to households and businesses throughout Toronto, and would constitute the largest fibre deployment ever in Canada. When summed across the two years it will take to complete, the capital expenditures associated with the project would total approximately $1 billion.

Broadband investment generates numerous social benefits for a community, and has been shown to enhance residents' quality of life, boost business productivity, provide the most reliable and resilient infrastructure, increase property values, and lure talent away from rival cities. This Policy Brief seeks to quantify two benefits in particular – employment and output effects.

As a general matter, investment of $1 in the economy has more than $1 impact on economic activity. This is because investment creates demand for material and human inputs into the investment activity, which in turn creates demand for further upstream inputs, which triggers further economy activity. In addition to creating direct jobs in areas such as network construction and deployment, an investment on the scale contemplated here stands to create indirect and induced jobs in related upstream industries and even in unrelated industries.

The "total employment" multiplier summarizes the combined effect from direct, indirect, and induced economic activity. Based on total employment multipliers that are general to communica-

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tions engineering construction and to FTTH in particular, the annual number of nationwide jobs that would be sustained by those FTTH investments should be at least 3,700, with the potential to reach 9,300 jobs depending on local economic conditions. Roughly 87 percent of those jobs should be created within the province of Ontario, given Toronto's contribution to Ontario employment, much of that job creation likely will take place in Toronto.

Importantly, these multiplier-based estimates do not fully capture the likely "spillover" effects of greater broadband investment and penetration in related downstream industries and in industries that broadband services are newly creating. For example, by enabling more regular contact between patient and caregiver, the use of broadband connections can mean earlier detection of health problems and better outcomes that enable people to live longer and enjoy more satisfying lives. Data networks can serve as the basis for new smart electrical grids, with communication via broadband enabling consumers to receive real time data on their consumption and on overall supply and demand. "Infostructure" investment can and should substitute for infrastructure, so that the faster we deploy broadband connections, the more telecommuting will occur, decreasing the need to build more highways and therefore permitting a greener planet overall.

These spillover effects could generate even more jobs in Toronto. Based on prior estimates used to study broadband investment, an additional 4,000 to 9,900 jobs could be created due to spillover effects, bringing the total jobs sustained by Bell Canada's investment to 7,700 to 19,200 over the two years of the project. To put this job creation in perspective, employment in Ontario increased by 53,100 between November 2013 and November 2014. Had this investment occurred during those years, the Toronto FTTH project would have contributed between 14.6 and 36.3 percent of the province's recent employment growth.

With respect to predicted output effects, the Toronto FTTH project should generate between $0.9 and $1.5 billion in annual nationwide economic output over each of the next two years. Table 1 summarizes the impact of Bell Canada's planned FTTH deployment in Toronto on employment and output.

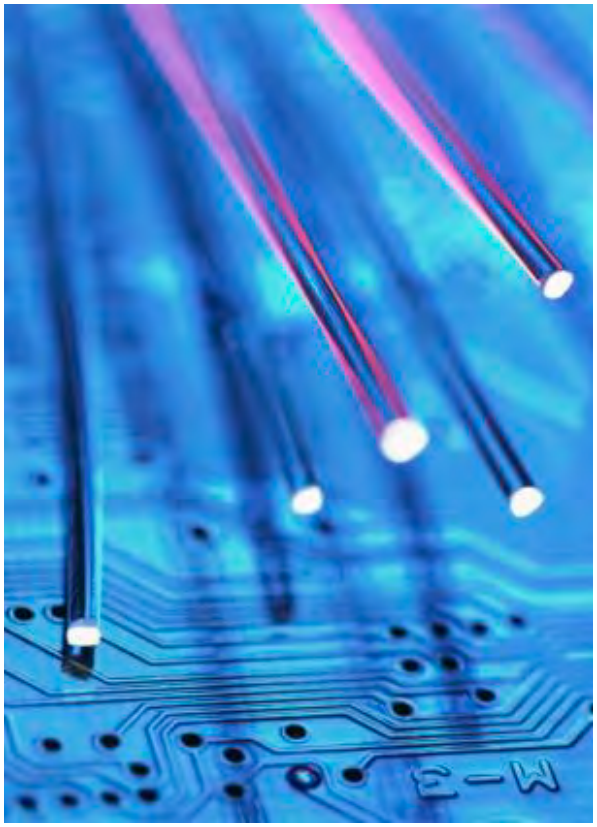
Thus, the Toronto FTTH project has the potential to generate nearly $3 billion in higher economic output (equal to $1.483 billion per year over two years) for the Canadian economy. Based on Ontario-specific multipliers, roughly 88 percent of that output should occur within the province, contributing between 5.3 and 8.2 percent of the province's expected output growth in both years based on recent trends. Ongoing maintenance of the network plus future upgrades, as well as new establishments taking root in Toronto, imply that a significant portion of the economic impact will endure for years.

Summary

Table 1
Jobs and Economic Output Supported

	Comm. Engineering Construction Multiplier	FTTH Specific Multiplier
Jobs - Total Multiplier*	3,783	9,358
Spillover Jobs	4,010	9,919
Total Jobs	7,793	19,277
Annual Economic Output*	$0.967B	$1.483B

* Direct, indirect, and induced effects.
Source: Author's calculations.



In addition to these well-studied impacts, broadband investment has been shown to enhance residents' quality of life, boost business productivity, provide the most reliable and resilient infrastructure, increase property values, and lure talent away from rival cities.

I. Introduction

Ontario is the largest economy in Canada, accounting for approximately 37 percent of Canada's gross domestic product (GDP) in 2013,[1] and Ontario is home to healthy banking and manufacturing sectors that contribute significantly to incomes, and some of the top academic institutions and healthcare facilities in the country. Given its proximity to the U.S. Midwest and Northeast regions, Ontario serves as a key linkage to the United States; it leads all provinces in exports.

Looking backwards, the Ontario economy lagged the Canadian national average in economic growth; the province's growth in real GDP from 2008 to 2013 (1.2 percent) ranked fifth in the nation,[2] trailing Manitoba (2.0 percent), Saskatchewan (2.6 percent), Alberta (2.8 percent) and British Columbia (1.6 percent) over the same time period. Non-residential investment has held steady between $70 and $80 billion per year since 2010,[3] but was expected to increase in 2014 due to planned capital expenditures by manufacturers and municipalities.

A key component to investment is broadband, which can transform a city through its unique ability to attract talent and spur economic activity in related markets. In 2014, Canada's Industry Minister adopted Digital Canada 150, a plan to stimulate the larger digital economy.[4] The drive to encourage broadband deployment is not just a federal initiative but a local one as well. The public agency Waterfront Toronto is building a Waterfront Innovation Centre in two buildings adjacent to a new park, "to house tech companies and draw on the ultra-high-speed broadband Internet service that they have brought into the area."[5] The Lambton County council is considering a multimillion-dollar plan to deploy broadband to rural southwestern Ontario communities, in an effort to offset recent job losses at the Ford,

1. Statistics Canada, Gross domestic product, expenditure-based, by province and territory, *available at* http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm (equal to 695.7 billion divided by 1.893 trillion).
2. RBC Economics, Provincial Outlook, Dec. 2014, at 6, *available at* http://www.rbc.com/economics/economic-reports/pdf/provincial-forecasts/provfcst-dec2014.pdf.
3. RBC Economics, Provincial Outlook, March 2014, at 6, *available at* http://www.rbc.com/economics/economic-reports/pdf/provincial-forecasts/provfcst-mar2014.pdf.
4. Canada and Industry Canada, Digital Canada 150, 2014, *available at* http://epe.lac-bac.gc.ca/100/201/301/weekly_checklist/2014/internet/w14-14-U-E.html/collections/collection_2014/ic/Iu64-48-2014-eng.pdf.
5. Alex Bozikovic, *Shored up: How Toronto's waterfront redevelopment is going right*, GLOBE & MAIL, July 25, 2014, *available at* http://www.theglobeandmail.com/news/toronto/shored-up-how-toronto-waterfront-redevelopment-is-going-right/article19784844/?page=all.

Kellogg's and Heinz plants in St. Thomas, London and Leamington, respectively.[6]

As broadband becomes more central to our lives, the speed of the broadband connection becomes increasingly important because faster speeds enable richer functionality and applications. Many of the applications of broadband Internet have become transformative in our personal and business lives because of the availability of very high-speed Internet connections. For example, telemedicine is changing the way that medicine is delivered, telecommuting is permitting more people to work from home, and "over-the-top" video service (video delivered over the consumer's home broadband connection either for free, such as from YouTube, or as a subscription service, such as Bell's CraveTV or Netflix), is allowing households to benefit from anytime, anyplace viewing. These services are either unavailable or less functional on lower-speed broadband connections.

Because so few cities have experienced FTTH deployment, and because the fortunate few have experienced it so recently, it is hard to quantify the benefits. For example, Bell Aliant's FibreOP is available to one million homes and businesses in more than 70 communities across Atlantic Canada and Ontario.[7] Greater Sudbury actually became the first community in Ontario with the next generation of FTTH communications delivered citywide. Analysts have been bullish about the potential benefits of these and other FTTH rollouts, including those in Austin, Texas, suggesting that FTTH could give a leg up to healthcare firms and generate substantial education applications.[8]

One possible place where the benefits of FTTH have been documented is Kansas City, Missouri, where a large scale fibre deployment by Google in began in late 2012. The city experienced an immediate 86 percent surge in the average connection speed,[9] and by the end of 2013, the city predicted that over 160,000 homes would be connected to the fibre network.[10] Most likely as a result of

6. Barbara Simpson, *Municipal governments asked to chip in $16M*, OBSERVER, Nov. 5, 2014, *available at* http://www.theobserver.ca/2014/11/05/municipal-governments-asked-to-chip-in-16m.

7. Bruce Erskine, *Bell Aliant bolsters fibre optic system*, HERALD BUSINESS, May 7, 2014, *available at* http://thechronicleherald.ca/business/1205963-bell-aliant-bolsters-fibre-optic-system.

8. Sam Gustin, *After Austin: Five Reasons You'll Want Google Fiber in Your City*, TIME, Apr. 11, 2013, *available at* http://business.time.com/2013/04/11/after-austin-five-reasons-youll-want-google-fiber-in-your-city/.

9. David Talbot, *Google Fiber's Ripple Effect*, MIT TECHNOLOGY REVIEW, Apr. 26, 2013, *available at* http://www.technologyreview.com/news/514176/google-fibers-ripple-effect/.

10. Drew Clark, 'Giganomics' Looks to Tech Entrepreneurship in Kansas City as New Model For Economic Development, BROADBANDBREAKFAST, Nov. 8, 2013, *available at* http://broadbandbreakfast.com/2013/11/giganomics-looks-to-tech-entrepreneurship-in-kansas-city-as-new-model-for-economic-development/.

the new network, the city has seen an increase in the number of startups, existing companies have relocated there, and new applications have been developed:

- As of 2013, Digital Sandbox, an incubator that had received $1 million in funding from the U.S. Department of Commerce, had a role in establishing 27 startups in Kansas City.[11]

- KC Startup Village, another Kansas City entrepreneur group, has provided low-cost office space to about 30 startup businesses since its inception in 2012.[12] One such startup is Leap 2, a Kansas-based mobile search application, which has raised over $2 million in initial investments since its inception in 2012.[13]

- Early access to FTTH allows startups to process and download heavy streams of data faster than normal. For example, EyeVerify, a biometrics company founded in 2012, has realized significant benefits by being able to utilize higher speeds for its eye-print verification software;[14] its software requires sending thousands of high-definition photos of retinas, which according to its creators, used to take hours but now takes only minutes.

- Other companies have moved into Kansas City to take advantage of the faster broadband capabilities. Cerner Corporation, which specializes in healthcare mobility and performance, has also agreed to purchase 237 acres to build a new campus that would employ up to 15,000 people in Kansas City.[15]

The University of Kansas Medical Center developed a gigabit medical application that will allow patients to consult with physicians without leaving their homes,[16] and in 2013, University of Kansas Medical Center began testing an application that would support caregivers of dementia patients.

11. *Id.*
12. *Id.*
13. Leap.it. Visual search collaboration platform, *available at* https://angel.co/leap-it.
14. Cecilia Kang, Google Fiber provides faster Internet and, cities hope, business growth, WASHINGTON POST, Jan. 25, 2013, *available at* http://www.washingtonpost.com/business/technology/google-fiber-provides-faster-internet-and-cities-hope-business-growth/2013/01/25/08b466fc-6028-11e2-b05a-605528f6b712_story.html.
15. Cerner Enters Into Agreement to Purchase Former Bannister Mall Site, Cerner, Aug. 1, 2013, *available at* http://www.cerner.com/Cerner_Enters_Into_Agreement_to_Purchase_Former_Bannister_Mall_Site/.
16. Sam Gustin, *After Austin: Five Reasons You'll Want Google Fiber in Your City*, TIME, Apr. 11, 2013, *available at* http://business.time.com/2013/04/11/after-austin-five-reasons-youll-want-google-fiber-in-your-city/.

Introduction

As the Kansas City FTTH experience makes clear, however, some of these benefits—such as attracting new talent or spurring new applications—are best described qualitatively, while other benefits such as employment[17] and economic growth[18] can be described quantitatively. The purpose of this Policy Brief is to quantify the magnitude of the benefits that a planned FTTH deployment in Toronto could have on employment and economic output in 2015 and 2016. The Policy Brief is organized as follows: In Section II, I review the state of broadband investment nationwide to provide context for the planned investment activity in Toronto. In Section III, I describe the planned FTTH investment of Bell Canada in Toronto. In Section IV, I estimate the number of jobs and economic output that could be sustained by FTTH investment in Toronto in 2015 and 2016. In Section V, I conclude.

As a general matter, investment of $1 in the economy has more than $1 impact on economic activity.

17. *See* 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, *available at* https://research.stlouisfed.org/publications/red/2007/02/Shideler.pdf (showing that broadband deployment contributes from 0.14 to 5.32 percent to total employment growth depending on the industry being studied). *See also* 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 (showing that for every one percentage point increase in broadband penetration in a state, employment increases by 0.2 to 0.3 percent per year.).
18. *See* David Sosa, Early Evidence Suggests Gigabit Broadband Drives GDP, Sept. 2014, *available at* http://www.analysisgroup.com/article.aspx?id=15613 (showing that 14 gigabit broadband communities exhibited a per capita GDP approximately 1.1 percent higher than the 41 similar communities with little to no availability of gigabit services, leading to $1.4 billion in added output).

II. National Trends in Broadband Investments in Canada

Canada ranks among the world's leading nations when it comes to broadband deployment. According to a G7 survey by Richard Bennett of the American Enterprise Institute, Canada is tied with the United States in a composite measure that considers eight criteria comprising geography, deployment, adoption, and usage.[19] Canada achieves this high ranking despite having the hardest rural-addressability problem to solve among the G7.[20]

Canada is presently experiencing investment in "next generation" broadband technologies. By 2013, 15 percent of Canadian homes were covered by "fibre to the premises" or FTTH,[21] 58 percent were passed by telco-based "fibre to the node"[22]—an intermediate fibre technology that stops short of bringing fibre to the subscriber's home—and 95 percent of all homes were passed by cable-based fibre to the node (aka DOCSIS 3.x).[23] By 2013, 81 percent of broadband connections were served by *at least one* provider capable of achieving download speeds in excess of 25 Mbps.[24] In Ontario, 84 percent of households were served by *at least one provider* capable of achieving download speeds of 25 Mbps.[25]

Wireless broadband is often treated as a separate category, despite the fact that wireless is taking on an increasingly important role in future broadband investment. Although wireless broadband is not the focus of this paper, it bears noting that wireline investment of the kind contemplated by Bell Canada in Toronto is required to handle the growth in data used by wireless devices. In particular, cell towers need access to fibre to offload the data traffic and people at home tend to use Wi-Fi to offload wireless traffic in home.

19. Richard Bennett, G7 Broadband Dynamics Scorecard, AEI Publication, Nov. 2014, at vii, *available at* https://www.aei.org/wp-content/uploads/2014/11/G7-Broadband-Dynamics-Final.pdf.
20. *Id*. at viii.
21. 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 520,000 FTTH connections in Canada. *See also* RVA Market Research, *supra*, at slide 6.
22. CRTC, Communications Monitoring Report 2014, Figure 5.1.5 (equal to 7.8 million homes divided by 13.3 million nationwide homes).
23. *Id*. (equal to 12.6 million homes divided by 13.3 million nationwide homes).
24. CRTC, Communications Monitoring Report 2014, Table 5.3.12.
25. *Id.* Table 5.3.13.

III. Planned Investment in Toronto

BCE expends approximately $3.5 billion annually in capital to enhance its telecommunications networks in Canada.[26] In Atlantic Canada alone, Bell Canada has planned close to $2.1 billion in capital investment over the next five years in broadband wireline and wireless networks.[27] The employment effects of those capital expenditures extend beyond the company's direct employees.[28] According to "total" job multipliers from Statistics Canada—equal to the sum of direct, indirect, and induced jobs—$1 million of investment in communications engineering construction—the closest available industry code kept by Statistics Canada—supports between 6.5 and 13.4 jobs across Canada, depending on the province in which the investment takes place.[29]

Direct effects are jobs generated from activities such as installing fibre, while indirect effects are job gains associated with communication equipment suppliers. Induced effects are the jobs created because the employees of an input provider use their additional income to purchase more goods and services in the local economy. These three effects (direct, indirect, and induced)—collectively referred to as the "total" multiplier—are considered to be the key elements of a traditional analysis of economic impact. Accordingly, before considering any spillover effects from broadband investment, every $1 billion of capital expenditure by Bell Canada supports between 6,500 and 13,400 jobs across Canada.

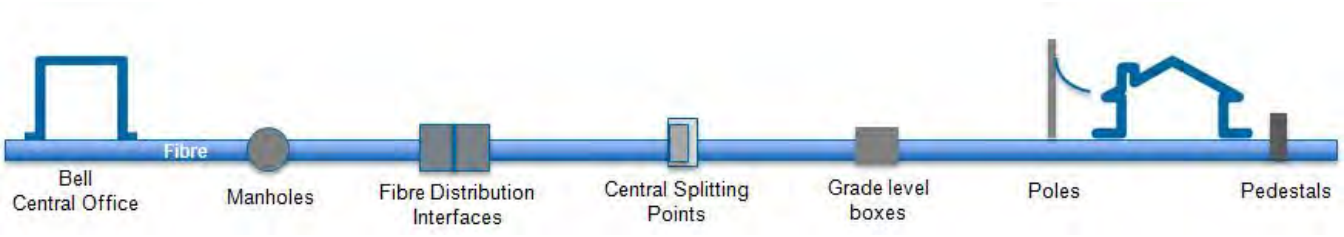
A planned fibre deployment in Toronto has the potential to generate an even greater impact on employment and economic activity—not just in the telecommunications industry, but also in related industries such as online applications, healthcare, education, and financial services. The project aims to deliver fibre to households and businesses throughout Toronto, which would constitute the largest fibre deployment ever in Canada.

26. BCE Inc., 2013 Annual Report, at 51, *available at* http://www.bce.ca/assets/investors/AR_2013/BCE_2013_Annual_Report.pdf.
27. *Bell Boosts Broadband in Atlantic Canada with Acquisition, Investment, Privatization Plans*, MEDIACASTER, Jul. 23, 2014, *available at* http://www.mediacastermagazine.com/news/bell-boosts-broadband-in-atlantic-canada-with-acquisition-investment-privatization-plans/1003171114/?&er=NA.
28. *Id.* at 9 ("A re-energized team of more than 55,000 Bell employees in every province and territory is transforming our company in remarkable ways . . .").
29. Jobs Multipliers, Statistics Canada, industry code BS23C400 "Communications engineering construction," *available at* http://www5.statcan.gc.ca/olc-cel/olc.action?objId=15F0046X&objType=2&lang=en&limit=0. For every $1 million of investment, 6.19 jobs are created via "direct" and "indirect" effects, under the assumption that there is no feedback between wages and production. Another 1.78 jobs (equal to 7.97 less 6.19) are estimated to be "induced," under the assumption that payments for labor services are redirected in the economy through consumer expenditures.

When summed across the two years it will take to complete, the capital expenditures associated with the Project would total approximately $1 billion (or $475 million per year for two years). In addition to creating direct jobs in areas such as network construction and deployment, this massive investment stands to enhance residents' quality of life, boost business productivity, provide the most reliable and resilient infrastructure, increase property values, and lure talent to Toronto (potentially at the expense of its tech-based rivals in the United States such as Boston and New York).

Figure 1 depicts the necessary infrastructure graphically, from Bell's central office to the customer's premises. The bulk of the investment (over 90 percent) will take the form of construction infrastructure and last-mile, as well as terminal and inside wiring. This is critical because construction has relatively high employment and output multipliers in the Statistics Canada database.

Figure 1
Necessary Infrastructure



Source: Bell Canada.

Bell Canada has internally estimated that the Toronto FTTH project will utilize 3,100 laborers in the Toronto area. According to Statistics Canada's total job multiplier for "communications engineering construction" in Ontario[30] (equal to 7.97), the FTTH project should sustain roughly 3,783 jobs (equal to 475 x 7.97 jobs)—not counting spillover effects—for two years assuming the $950 million in total investment is divided equally across time periods.

But even the estimate based on Statistics Canada's total multiplier (which corresponds closely to Bell Canada's internal labor estimate) is conservative given the types of non-fibre investments included in "communications engineering construction." This multiplier of a modest eight jobs per million of investment is based on an average effect from investment in (1) cables and lines (coaxial, copper, aluminum), (2) optical fibre (aerial, underground, submarine), and (3) transmission support structures (towers, polls, conduits).[31] To the extent that fibre uses relatively more labor than these other components, then a weighted average will be downwardly biased. By comparison, in 2003, the Strategic Networks Group used an input-output model to estimate the impact of a small fibre investment by the township of South Dundas,[32] arriving at 48 jobs per million invested[33]—*six times* the multiplier im-

30. The multipliers are not available at the municipal level.

31. Statistics Canada, Annual Capital and Repair Expenditures Survey Actual for 2013, at 7.

32. Department of Trade and Industry, Economic Impact Study of the South Dundas Township Fibre Network (Jun. 2003), *available at* http://www.sngroup.com/wp-content/uploads/2011/03/DTI-SD-Case-Study_Final_Issued-June-27-2003.pdf.

33. Equal to 62.5 jobs divided by $1.3 million invested.

plied by Statistics Canada for "communications engineering construction." In the job effects section below, I re-estimate the effects based on FTTH-specific multipliers in the United States.[34]

IV. Impact of Planned Investment

Although broadband investment generates myriad benefits—including increased competition (resulting in lower prices and faster speeds),[35] greater productivity,[36] greater property values,[37] attracting human capital or businesses from rival cities, improvements in access to services such as healthcare and education—I focus on the creation of jobs and economic output here.

A. Overview

As a general matter, investment of $1 in the economy has more than $1 impact on economy activity. This is because investment creates demand for material and human inputs into the investment activity, which in turn creates demand for further upstream inputs, which triggers further economy activity. In addition, when the economy is not at full employment, investment creates jobs, and additional employment stimulates increased demand for goods and services by newly employed workers.

Although these ripple effects differ from industry to industry, they can be estimated. Both Statistics Canada and the U.S. Bureau of Economic Analysis ("BEA") conduct such analyses and periodically publish multipliers that permit one to quantify the effect throughout the economy of investment in a given industry on jobs and output. The multiplier analysis measures both direct and indirect effects of a particular investment. Alt-

34. Jeffrey A. Eisenach, Hal J. Singer & Jeffrey D. West, *Economic Effects of Tax Incentives for Broadband Infrastructure Deployment*, Fiber-to-the-Home Council (2008) at 8.
35. Scott Wallsten & Colleen Mallahan, Residential Broadband Competition in the United States, March 2010, at 25 (finding that cable modem prices are generally lower and speeds are generally faster where there are more wireline providers). *See also* Debra J. Aron & David E. Burnstein, Broadband Adoption in the United States: An Empirical Analysis, March 2003, *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=386100; GAO, Subscriber Rates and Competition in the Cable Television Industry GAO-04-262T, Mar 25, 2004, *available at* http://www.gao.gov/products/GAO-04-262T.
36. Robert Litan & Hal Varian, The Net Impact Study The Projected Economic Benefits of the Internet In the United States, United Kingdom, France and Germany, at 6 (Jan. 2002), *available at* http://www.itu.int/wsis/stocktaking/docs/activities/1288617396/NetImpact_Study_Report_Brookings.pdf; Chris Forman, Avi Goldfarb, & Shane Greenstein, *Geographic Location and Diffusion of Internet Technology*, 4(1) ELECTRONIC COMMERCE RESEARCH AND APPLICATIONS 1-13 (2005); Lynne Holt & Mark A. Jamison, Broadband and Contributions to Economic Growth: The U.S. Experience and Future Direction, August 2008, *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1535472; Stephen D. Oliner, Daniel E. Sichel, Kevin J. Stiroh, Explaining a Productive Decade, December 2007, FEDS Working Paper No. 2007-63, *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1160248#.
37. *See* Molnar, Savage & Sicker, *supra*.

hough one could potentially determine the number of employees hired by equipment manufacturers as a direct result of increased demand, it would be nearly impossible to measure the indirect effect of those employees' consumption on other industries without the use of the multipliers.

As in other industries, broadband capital expenditures have a multiplicative effect on job creation and economic output if the economy is at less than full employment.[38] The multiplier specific to telecom equipment manufacturers translates the effect of telecommunications capital spending on Canadian employment and on economic output.[39]

38. The multiplier is a standard principle in the macroeconomics literature. *See, e.g.,* RUDIGER DORNBUSCH & STANLEY FISCHER, MACROECONOMICS 66 (McGraw Hill 6th ed. 1994). Richard Kahn first introduced the multiplier concept as an "employment multiplier." *See* Richard F. Kahn, *The Relation of Home Investment To Employment,* 41 ECON. J. 173, 173-98 (1931). John Maynard Keynes expanded upon this concept by introducing the "investment multiplier." *See* JOHN MAYNARD KEYES, A GENERAL THEORY OF EMPLOYMENT, INTEREST, AND MONEY 115 (Harcourt Brace & Co. 1964) (1936).

39. Analogous to the effects in other industries, the multiplicative effect in the telecommunications industry occurs because higher expenditures on telecommunications equipment—equivalent to higher demand for the products of equipment manufacturers—cause equipment manufacturers to hire more employees to meet the increased demand. The equipment manufacturers' incomes increase as well due to the increased expenditures, which, according to the consumption function, will increase their consumption as well. The increased consumption of equipment manufacturers will in turn increase the income and employment of their suppliers. The income and employment of those suppliers will then increase, and so on. An employment multiplier of 20 for telephone apparatus manufacturing would indicate that 20 jobs would be created nationally for every $1 million invested in that sector. The timeframe over which these benefits are accrued is debatable. The BEA suggests that one year is the appropriate time horizon for the multipliers to achieve their full effect. Other economists, however, have estimated that it may take as long as two years.

B. Job Creation

My analysis of employment effects from greater broadband investment is divided into two parts: (1) "total multiplier effects," which estimates the number of jobs directly and indirectly created by spending activities in upstream (input) industries, plus induced jobs from greater household income; and (2) "spillover effects," which accounts for additional spending by related and new downstream industries that benefit indirectly from additional broadband investment and penetration.

1. Total Multiplier Effects

Previous research has applied the U.S. Bureau of Economics ("BEA") multipliers to quantify the effect of nationwide broadband on nationwide employment and productivity. Using the BEA job and output multipliers, along with slated broadband investment schedules from the Columbia Institute for Tele-Information, Crandall and Singer (2010) projected an average of 509,546 jobs in the United States would be sustained from 2010 to 2015 as a result of approximately $30.4 bil-

lion of annual broadband investments relative to a world without such investments,[40] implying a weighted-average multiplier (across all broadband technologies) of 16.8 jobs for every million dollars of broadband investment.

Katz and Callorda (2014) studied the effects of repealing a sales tax exemption in Minnesota on the telecommunications industry.[41] Based on an input-output analysis, they estimate that a $154 million reduction in broadband investment would destroy 3,323 jobs in the state, implying a total job multiplier of 21.6 jobs per million dollars of broadband investment.[42] Indirect and induced effects contribute a substantial proportion of that total multiplier.[43]

Sosa and Audenrode (2012) estimated that the effects of reassigning 300 MHz of additional spectrum to mobile broadband would trigger $15.075 billion in new capital spending per year (although the study pertains to mobile broadband, the authors rely on job multipliers derived from wireline services).[44] The authors apply BEA Type II RIMS multipliers to calculate a weighted average of Construction (56%) and Broadcast and Communications Equipment (44%), implying 20.4 jobs for every $1 million invested.[45] Thus, the new spectrum was estimated to generate 307,619 jobs over the investment period (equal to the product of $15,075 and 20.4 jobs per million dollars). The authors explain that these estimates represent only a portion of the economic benefits that flow from broadband investment. For example, infusing additional spectrum into the mobile broadband market could also "spur development and commercialization of new products and services that may be difficult for most of us to imagine at the present."[46]

Using the latest multipliers for telephone apparatus manufacturing (11.8), broadcast and wireless communications equipment (13.8), fibre-optic cable manufacturing (14.4),

40. Robert W. Crandall & Hal J. Singer, The Economic Impact of Broadband Investment, Prepared for Broadband for America, Feb. 2010, *available at* http://internetinnovation.org/files/special-reports/Economic_Impact_of_Broadband_Investment_Broadband_for_America_.pdf.
41. Raul Katz & Fernando Callorda, Assessment of the Economic Ompact of the Repeal of the Tax Exemption on Telecommunication Investment in Minnesota (Feb. 2014), *available at* http://www.mncca.com/doc/minnesota-study-final-version.pdf.
42. *Id*. at 24.
43. *Id*.
44. David Sosa & Marc Van Audenrode, Private Sector Investment and Employment Impacts of Reassigning Spectrum to Mobile Broadband in the United States, Analysis Group (August 2011), *available at* http://www.analysisgroup.com/uploadedFiles/News_and_Events/News/Sosa_Audenrode_SpectrumImpactStudy_Aug2011.pdf.
45. *Id*. at 5.
46. *Id*. at 7.

and construction (26.7),[47] Eisenach, Singer and West (2009) estimated separate multipliers for different types of broadband spending by applying weights to each of the industry multipliers based on the allocation of broadband capital spending to each industry.[48] They estimated the weighted average employment multipliers for fibre-based technologies of 19.7 jobs per million of FTTH investment.[49] Singer and West (2010) applied this multiplier to estimate the effect of various tax incentives for broadband deployment.[50]

Table 2 summarizes the relevant literature on the total multiplier effects from broadband investment. Given the consistency with which various researchers have used a multiplier of approximately 20 jobs per million of investment, I adopt the FTTH-specific multiplier from Singer and West (2010). As a crosscheck, I also present estimates based on the Statistics Canada multiplier for communications engineering construction. Table 3 summarizes the results. Based on these estimates, before considering any spillover effects, Bell Canada's FTTH investment in Toronto should sustain at least 3,783 jobs nationwide in 2015 and 2016, with the potential to sustain 9,358 jobs depending on economic conditions within Ontario.

It bears noting that the BEA's RIMS data used for the FTTH-specific multiplier was measured at a time (2008) of particularly weak demand in the United States—that is, when there was significant slack in the U.S. economy—which could have the effect of overstating the impact of a dollar's worth of investment in a more robust economy; the capacity of an investment to inject a stimulus is much greater when the investment does not come at the expense of other opportunities. On the other hand, the generic construction multiplier from Statistics Canada tends to understate the likely impact of FTTH investment given its weighting of technologies that are not as construction-intensive as FTTH. For these reasons, the most likely outcome is some point in between the two estimates.

47. U.S. DEPARTMENT OF COMMERCE, BUREAU OF ECONOMIC ANALYSIS, Regional Input-Output Modeling System (RIMS II), Table 1.5 (2008). Multipliers are based on the 1997 Benchmark Input-Output Table for the Nation and 2006 regional data.
48. Jeffrey A. Eisenach, Hal J. Singer, & Jeffrey D. West, *Economic Effects of Tax Incentives for Broadband Infrastructure Deployment*, Fiber-to-the-Home Council (2008) at 8.
49. *Id.* Table 2 at 8. FTTH weights are 30 percent for telephone apparatus manufacturing, 20 percent for fibre optic cable manufacturing, and 50 percent for construction.
50. Hal J. Singer & Jeffrey D. West, Economic Effects Of Broadband Infrastructure Deployment and Tax Incentives For Broadband Deployment, prepared for Fiber-to-the-Home Council, March 2010, *available at* www.ftthcouncil.org/d/do/72.

Table 2
Summary of Total Multipliers from Broadband Investment

Study	Annual Investment (billions)	Projected Total Jobs (000s)	Total Multiplier	Method
Crandall & Singer (2010)	$30.4	509.5	16.8	Multiplier
Sosa & Audenrode (2012)	$15.1	307.6	20.4	Multiplier
Katz & Callorda (2014)	$0.154	3.3	21.6	Input-Output
Singer & West (2010)	$12.7	250.4	19.7	Multiplier
Atkinson, Castro & Ezell (2009)	$10.0	229.5	22.9	Multiplier

Notes: Total multiplier is the sum of direct, indirect, and induced effects.

Table 3
Jobs Supported by Toronto FTTH Project
(Based on Total Multiplier)

Year	Comm. Engineering Construction Multiplier	FTTH Specific Multiplier
2015 – 2016	3,783	9,358

Source: Author's calculations.

In addition to the nationwide multipliers, Statistics Canada makes available multiplier effects within a given province, which quantify the effect of investments in a particular province on employment and output. The total employment multiplier for communications engineering construction within Ontario is 6.95.[51] Thus, 87.2 percent of the jobs (equal to 6.95 divided by 7.97) or between 3,301 (the low-end estimate from Table 3) and 8,159 (the high-end estimate from Table 3) jobs should materialize within Ontario, with most likely within the Greater Toronto Area. Given Toronto's contribution to Ontario employment,[52] much of that job creation likely will take place in Toronto. To put these numbers in perspective, employment in Ontario increased by 53,100 between November

51. Industry Accounts Division / Statistics Canada, Provincial Input-Output Multipliers, 2010, Ontario.
52. In 2014, Toronto's contribution to Ontario's employment stood at 47.2 percent (equal to 3,296.1 divided by 6,969.0). Statistics Canada, Labour force characteristics, *available at* http://www.statcan.gc.ca/pub/71-001-x/2014012/t021-eng.htm.

2013 and November 2014.[53] Had this investment occurred during those years, the Toronto FTTH project would have contributed between 7.1 and 17.6 percent of the province's recent employment growth (not including spillover effects).

2. Spillover Effects

As noted above, the total multipliers I use to estimate the effects of broadband investment on employment and economic activity model the direct, indirect, and induced effects but not the "spillover" effects of the investment.[54] Stated differently, the multiplier-based jobs estimate does not account for additional spending in related downstream industries except for those industries that directly benefit from increased spending by broadband input providers.

Yet broadband investment and higher broadband penetration have been shown to create additional, or "spillover" effects in downstream industries, including in healthcare, education, and energy, whose ability to enrich and enhance their service offerings is increased by greater availability of broadband Internet access. For example, using online help-wanted ads as a guide to the location of app-related jobs, Mandel and Scherer (2012) estimated the number of app-related jobs per U.S. state as of April 2012.[55] Such spillover effects into app-related industries largely would be neglected by and are excluded from, the total multiplier effect presented in Table 3. To the extent that broadband investment induces extra spending in those industries, the job impact in Ontario is even greater than the direct and indi-

53. Statistics Canada, Labour force characteristics, seasonally adjusted, by province, available at http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/lfss01b-eng.htm.

54. Statistics Canada, Provincial Input-Output Multipliers, 2010, Notes ("Direct effects measure the initial requirements for an extra dollar's worth of output of a given industry. The direct effect on the output of an industry is a one dollar change in output to meet the change of one dollar in final demand. Associated with this change, there will also be direct effects on GDP, jobs, and imports. Indirect effects measure the changes due to inter-industry purchases as they respond to the new demands of the directly affected industries. This includes all the chain reaction of output up the production stream since each of the products purchased will require, in turn, the production of various inputs. Induced effects measure the changes in the production of goods and services in response to consumer expenditures induced by household"). *RIMS II: An Essential Tool for Regional Developers and Planners*, Bureau of Economic Analysis, U.S. Department of Commerce, at 2-2 ("RIMS II is a backward-linkage model. To give an example of the impact measured by RIMS II, consider the expansion of a warehouse. The impacts of the expansion estimated with the model's multipliers will account for the increase in demand for inputs by the warehouse but will not account for increase in production by the industries that may use the warehouse.").

55. Mike Mandel & Judith Scherer, The Geography of the App Economy, Sept. 2012 (prepared for CTIA).

rect upstream effects captured by the multipliers.

Spillover effects can materialize in myriad ways. For example, by enabling more regular contact between patient and caregiver, the use of broadband connections can mean earlier detection of health problems and better outcomes that enable people to live longer and enjoy more satisfying lives.[56] Providing broadband connection speeds and continuous network connections can facilitate distance-learning opportunities through teleconferencing; such technology may have particular benefits for rural communities that may lack access to top-flight educational resources.[57] Data networks can serve as the basis for new smart electrical grids, with communication via broadband enabling consumers to receive real time data on their consumption and on overall supply and demand. "Infostructure" investment can and should substitute for infrastructure, so that the faster we deploy broadband connections, the more telecommuting will occur, decreasing automobile travel and congestion significantly,[58] thereby decreasing the need to build more highways and permitting a greener planet.[59] FTTH connections have been credited with changing how employees work, electing to work more days from home.[60]

Broadband spillover effects tend to concentrate in service industries such as financial

56. M. Meyer, R. Kobb, & R. Ryan, *Virtually healthy: Chronic disease management in the home*, 5 DISEASE MANAGEMENT 87-94 (2002).
57. Working Party on Communication Infrastructures and Services Policy, Network Developments in Support of Innovation and User Needs, Organization for Economic Cooperation and Development Dec. 2009 at 5 (Broadband is having a significant impact on education and e-learning by improving access to digital learning resources; encouraging communication among schools, teachers and pupils; promoting professional education for teachers; and linking local, regional, and national databases for administrative purposes or supervision.") *available at* http://www.olis.oecd.org/olis/2009doc.nsf/LinkTo/NT0000889E/$FILE/JT03275973.PDF [hereafter *OECD report*].
58. *See, e.g.*, Joseph Fuhr and Stephen Pociask, Broadband and Telecommuting: Helping the U.S. Environment and the Economy, Low Carbon Economy, 2011, 41-47, available at http://file.scirp.org/Html/4227.html ("Studies show that telecommuters reduce daily trips on days that they telecommute by up to 51% and automobile travel by up to 77%. "); Justin Horner, Telework: Saving Gas and Reducing Traffic from the Comfort of your Home, Mobility Choice, *available a*t http://www.mobilitychoice.org/MCtelecommuting.pdf ("By taking more than 4.7 million cars off the road every day, telecommuting already has a positive effect on congestion."); Ted Balaker, The Quiet Success: Telecommuting's Impact on Transportation and Beyond, Reason, Nov. 2005, *available at* http://reason.org/files/853263d6e320c39bfcedde642d1e16fe.pdf ("In fact, an analysis of Washington D.C. commuting by George Mason University's Laurie Schintler found that traffic delays would drop by 10 percent for every 3 percent of commuters who work at home.").
59. Walter Russell Mead, *Infostructure Is the New Infrastructure*, WALL ST. J., Oct. 15, 2012, *available at* http://online.wsj.com/article/SB10000872396390443816804578000690515270954.html.
60. RVA Market Research, *supra*, slide 18. *Id*. at slide 48 (employed FTTH users say they work 1.3 extra days per month from home).

services and healthcare, yet some have identified an effect in manufacturing as well.[61] In light of the recognized limitations of the multiplier approach for capturing the full economic effect of investment activities, economists have developed alternative methods and tools to estimate the full effects of broadband investment and use. For example, broadband investment has been credited with stimulating spending by application developers, who seek to exploit business opportunities created by faster and more ubiquitous broadband connections. Four studies are particularly relevant.

Crandall and Singer (2010) estimate spillover effects by examining how added spending in related upstream markets could impact employment.[62] They assume that capital expenditures in related upstream markets—such as educational services, healthcare services, publishing industries, motion picture and sound recording, amusements and recreation services, computer and electronic products—are likely to increase as faster Internet connections become available and broadband subscriptions grow. Using industry-specific employment multipliers and an assumed five percent increase in capital expenditure, they estimate an additional 452,081 jobs on top of the 509,546 jobs created via the total multiplier, implying a spillover multiplier of 0.89.

Katz and Suter (2009) describe how "network-effect-driven" job gains flow from three trends: innovation leading to the creation of new services, attraction of jobs (from either other U.S. regions or overseas), and productivity enhancement.[63] They calculate the impact of innovation on the professional services sector, by applying the ratio of productivity gains to the creation of new employment, and applying this effect to the economy of the states with the lowest relative broadband penetration. The underlying assumption of this estimate is that "the economy can generate enough jobs through innovation in a rate comparable to productivity gains."[64] From these gains, they subtract (1) the net jobs lost due to accelerated outsourcing from increased broadband penetration, and (2) the jobs lost due to more efficient processes enabled by broadband. They estimate that this (net) spillover multiplier can range from 0.07 to 7.28 of the direct ef-

61. Crandall, Lehr, & Litan, *supra.*
62. Robert W. Crandall & Hal J. Singer, The Economic Impact of Broadband Investment, Prepared for Broadband for America, Feb. 2010, *available at* http://internetinnovation.org/files/special-reports/Economic_Impact_of_Broadband_Investment_Broadband_for_America_.pdf.
63. Raul Katz & Stephan Suter, *Estimating the Economic Impact of the Broadband Stimulus Plan*, at 20.
64. *Id*. at 21.

fects, with a mid-point estimate of 3.65.[65] Expressed as a multiple of the total multiplier effect (direct, indirect, and induced effects combined), their midpoint estimate is slightly above one.

Atkinson, Castro and Ezell (2009) also examine the impact of spillover effects.[66] They explain how broadband investment facilitates (1) innovative applications such as telemedicine, e-commerce, online education and social networking; (2) new forms of commerce and financial intermediation; (3) mass customization of products; and (4) marketing of excess inventories and optimization of supply chains. They explain that network externalities should not decline with the build out of networks and maturing technology over time because penetration has not reached 100 percent and because faster connections should permit a new round of application innovation. Based on a $10 billion broadband investment program, they estimate 268,480 jobs via spillover effects, and 229,475 jobs via direct/indirect/induced effects, implying a spillover multiplier of 1.17.

A 2013 study by The Wireless Infrastructure Association explained how new technologies have been made possible as wireless broadband exceeded a critical threshold where innovators and users of new technologies "can move forward with their business plans with the knowledge that the underlying infrastructure will be there to serve them."[67] For example, the technology for mobile payments has been growing due to the pervasiveness of wireless broadband infrastructure.[68] Although their study focuses on the impact of wireless broadband investments, it nevertheless offers another application of the spillover effect (employing the high-end of the range estimated by Katz and Suter).

Table 4 summarizes the relevant economic literature on spillover effects. Given the consistency with which various researchers have used a spillover multiplier of slightly over one additional network-induced job per every job created via the total multiplier, I adopt the spillover estimate from Katz and Suter (2009) of 1.06.

65. *Id*. at 26.
66. Robert D. Atkinson, Daniel Castro and Stephen J. Ezell, *The Digital Road to Recovery: A Stimulus Plan to Create Jobs, Boost Productivity and Revitalize America*, INFO. TECH. & INNOV. FOUND. (Jan. 2009), *available at* http://www.itif.org/files/roadtorecovery.pdf.
67. Alan Perce, Richard Carlson, and Michael Pagano, Wireless Broadband Infrastructure: A Catalyst for GDP and Job Growth 2013-2017, PCIA (Sep. 2013), 9, *available at* http://www.pcia.com/images/IAE_Infrastructure_and_Economy_Fall_2013.PDF.
68. Gartner, Gartner Says Wordlwide Mobile Payment Transaction Value to Surpass $171.5 Billion, Press Release, May 29, 2012, *available at* http://www.gartner.com/newsroom/id/2028315.

As shown in Table 5, via the spillover effect, Bell Canada's FTTH investment should sustain an additional 4,010 to 9,919 jobs, on top of the 3,783 to 9,358 jobs generated by the total multiplier. Thus, the total jobs from both the multiplier and the spillover effects could reach as high as 19,277 over the two-year period. Recall that employment in Ontario increased by 53,100 between November 2013 and November 2014.[69] Had this investment occurred during those years, the Toronto FTTH project would have contributed between 14.6 and 36.3 percent of the province's recent employment growth, including spillover jobs.

C. Economic Output

One can also measure the effect of broadband investment on economic output. Eisenach, Singer, and West estimate the weighted average output multipliers for FTTH investment (3.1293).[70] Again as a crosscheck, I employ the total output multiplier (direct, indirect, and induced) for communications engineering construction from Statistics Canada (2.0365).[71] I apply these multipliers to my annual broadband investment estimates in Table 6.

FTTH investment in Toronto is expected to generate between $0.967 and $1.483 billion in nationwide economic output over the next two years. Thus, over two years, the Toronto FTTH project has the potential to contribute nearly $3 billion (equal to $1.483 billion x 2) to the Canadian economy. Based on Statistics Canada's within-province multiplier for Ontario (1.804),[72] roughly 88.6 percent of that output boost likely will occur within the province of Ontario with most likely within the Greater Toronto Area. To put that figure in perspective, Ontario experienced an increase in output of $16.089 billion in 2013.[73]

Thus, an increase in annual output between $0.857 and $1.317 billion within the province of Ontario would have contributed between 5.3 to 8.2 percent to GDP growth in 2013.

69. Statistics Canada, Labour force characteristics, seasonally adjusted, by province, *available at* http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/lfss01b-eng.htm.
70. Eisenach, Singer, West, *supra*.
71. Industry Accounts Division / Statistics Canada, Provincial Input-Output Multipliers, 2010, Ontario.
72. *Id*.
73. Gross domestic product, expenditure-based, by province and territory, *available at* http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm.

Table 4
Summary of Spillover Effects from Broadband Investment

Study	Projected Total Jobs (000s)	Spillover Jobs (Spillover Multiplier) (000s)
Crandall and Singer (2010)	961.0[A]	452.0 (0.89)
PCIA (2013)	303.7[B]	194.9 (1.79)
Katz and Suter (2009)	263.9[C]	136.1 (1.06)
Atkinson, Castro, and Ezell (2009)	498.0[D]	268.5 (1.17)

Notes: Spillover jobs are the jobs created above and beyond those created by direct, indirect, and induced effects. The spillover multiplier is defined here as the ratio of spillover jobs to direct, indirect, and induced jobs.

[A] Equal to 509,000 direct jobs plus 452,000 spillover jobs.
[B] Equal to 26,777 direct jobs plus 82,027 indirect and induced jobs plus 194,937 spillover jobs.
[C] Equal to 37,300 direct jobs plus 31,000 indirect jobs and 59,500 induced jobs plus 136,100 spillover jobs.
[D] Equal to 64,000 direct jobs plus 166,000 indirect and induced jobs plus 268,500 spillover jobs.

Table 5
Total Jobs Supported by Toronto FTTH Investment Each Year

	Comm. Engineering Construction Multiplier	FTTH Specific Multiplier
Jobs - Total Multiplier*	3,783	9,358
Spillover Jobs	4,010	9,919
Total Jobs	7,793	19,277

* Direct, indirect, and induced effects.
Source: Author's calculations.

Table 6
Annual Economic Output Supported by Toronto FTTH Investment
($ Billions)

Year	Comm. Engineering Construction Multiplier	FTTH Specific Multiplier
2015 – 2016	0.967	1.483

* Direct, indirect, and induced effects.
Source: Author's calculations.

V. Conclusion

Both national policy and local stakeholders view it as a policy imperative to remove obstacles to the development of a modern, high-speed broadband infrastructure. The results previewed here demonstrate that broadband services not only open doors for transformative services in medicine, education, culture, and entertainment, but they materially benefit local and national economies through job creation and increased economic output.

The City of Toronto stands to benefit from increased private investment in new communications networks. In addition to contributing to job and economic growth, the social benefits will likely include greater productivity among workers, greater property values, attracting human capital or businesses from rival cities, and improvements in access to services such as healthcare and education. Consumers stand to benefit, as well, from a robust and competitive market for broadband providers.

Although this report focuses on the two-year horizon associated with the initial investment plan, the economic benefits of FTTH in Toronto should extend well beyond that period. Bell Canada will continue to inject funds to maintain and even upgrade the network as needed to satisfy consumer demand and meet competitive pressures. Those investments will trigger the same multiplicative effect (on a per-dollar basis) as the original investments for years to come. Moreover, new establishments such as application developers will likely take root in Toronto, creating permanent jobs that will last beyond the initial investment period. In this sense, the FTTH deployment can be analogized to an annuity, generating social benefits for Torontonians for years to come.