# Economic Benefits of Investing in Basic vs. Gigabit Broadband Infrastructure in Rural Eastern Ontario

***Policy Brief***

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**Eastern Ontario Wardens' Caucus (EOWC)**
**&**
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**Economic Benefits of Investing in Basic vs. Gigabit Broadband Infrastructure in Rural Eastern Ontario**

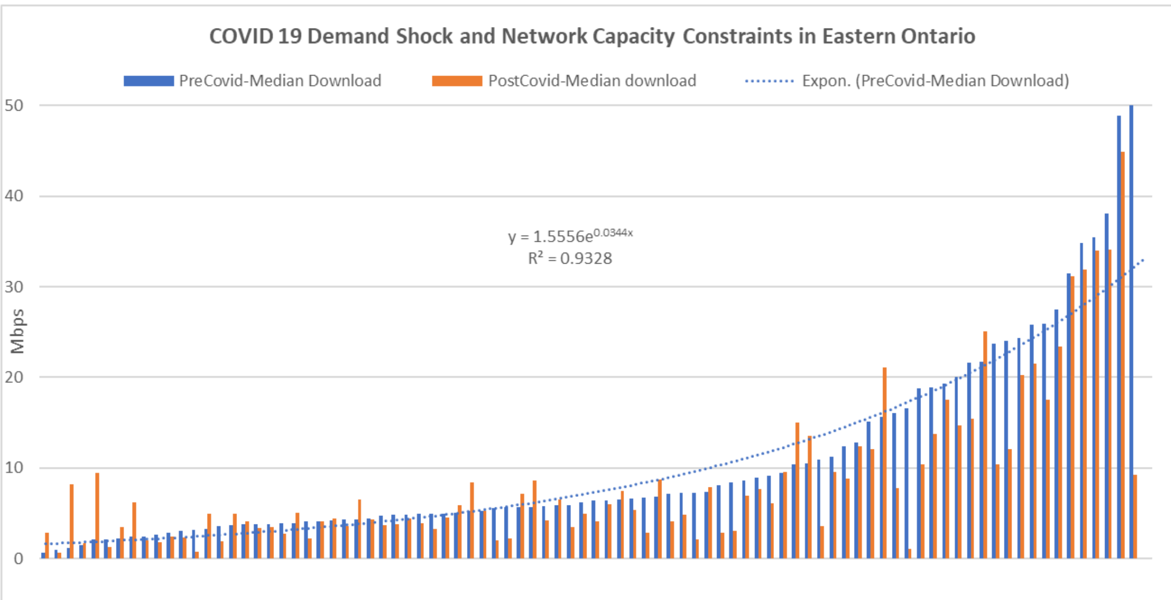


This report was commissioned by the Eastern Ontario Wardens' Caucus (EOWC)/Eastern Ontario Regional Network (EORN) and prepared by Dr. Reza Rajabiun. The views expressed herein are the author's alone and do not necessarily represent those of EOWC/EOWC, or any other affiliated organizations.

## Executive Summary

### Context

As part of their response to the COVID-19 pandemic, the Eastern Ontario Wardens' Caucus (EOWC) and the Eastern Ontario Leadership Council (EOLC) have prioritized improving the quality and affordability broadband Internet connectivity in the Region. To achieve this objective, the Eastern Ontario Regional Network (EORN) has developed two high-level technical strategies that aim to enhance broadband infrastructure capacity and service quality in underserved areas of the Region (i.e. those areas where services that meet the basic service speed targets defined by the Canadian Radio-television and Telecommunication Commission (CRTC) are not available). Having costed the options, EOWC/EORN aim to better understand how the two models differ in their potential economic benefits in order to assess against their fixed capital cost requirements.



Median download speeds in 90 municipal entities/test aggregation locations in Eastern Ontario; first quarter in 2020 vs post COVID lockdowns up to end of June 2020; Source: M-Lab

This report evaluates economic benefits of the two approaches EORN has developed for consideration by local and upper-tier policymakers. Based on data on maximum advertised speeds on offer, EORN estimates that around 50% of households in the Region lack access to services that meet CRTC's 50 Mbps download/10 Mbps upload speed basic service targets. Furthermore, Internet measurements document that in many communities in rural eastern Ontario effective median speed providers are able to deliver/users experience remain below 10 Mbps download and 2 Mbps upload. The rapid growth in demand for scarce network resources caused by COVID lockdowns has made the situation even worse in most areas of the Region. Relatively poor service quality levels suggest most people that live and work in these areas have little option but to rely on old and slow copper/DSL, oversubscribed fixed wireless plants, and satellite-based broadband technologies. While this level of service may have been considered good enough before COVID, with COVID the lack of access to reliable high-quality broadband seriously threatens the quality of life and the livelihoods of people that live and work in rural eastern Ontario.

In response, EOWC/EORN have developed two distinct approaches to increasing broadband speeds and promoting technological change. EORN's "basic service" regional network model design aims to incrementally improve speeds that are available in areas with sub-par service to 50 Mbps download/10 Mbps upload using a combination of middle and last mile fibre deployments (to approximately 100,000 premises) and wireless capacity upgrades (to approximately 150,000 premises in areas with relatively higher costs). EORN's "Gig" model design aims to expand ultra-high capacity fibre-to-the-premises (FTTP) access networks to around 95% of residents in underserved areas of the Region (to approximately 250,000 households/premises; 600,000 people).

EOWC/EORN estimate that the basic service option will require around $700 million in capital expenditures, while achieving the higher standards of the Gig model will require an investment of up to $1.6 billion. Given the relatively low expected rates of return in rural areas targeted for broadband improvements, EOWC/EORN estimate that the project options will require between 60% and 80% in public subsidies in order to attract the remaining amounts in complementary private sector investments. This translates to a difference in the fixed capital cost subsidy requirements of around $700 million between the two models ($500 mil. in subsidies for basic service model and $1.2 billion for the Gig model).

In broad terms, the basic service model aims to improve service levels up to universal service aspirational speed targets established by federal policymakers back in 2016.[1] The Gig model aims to expand access to ultra-low latency/high-quality broadband services at speeds and Quality of Service (QoS) standards that are comparable to those available in Canada's urban cores (including some of the larger cities in eastern Ontario). By design, the Gig model is superior in term of distributional efficiency gains and expanding equality of opportunity to participate in the information economy. The basic service model has the more modest objective of limiting the scope for underserved areas of the Region to fall further behind than they are today, while minimizing initial subsidies by deploying less capital intensive wireless broadband technologies in relatively high cost areas. In other words, the Gig model embodies a long-term value maximization design strategy/proposition, while the basic service model prioritizes short term capital cost minimization over long term value of high-quality connectivity to people that live and work in rural eastern Ontario.

## Objective and scope

In evaluating their options, EOWC/EORN need to better understand the potential differences in economic benefits that can flow from investing in the basic service vs. Gig technical design

[1] Telecom Regulatory Policy CRTC 2016-496. https://crtc.gc.ca/eng/archive/2016/2016-496.htm

models. The objective of this report to assess these differences, identify some of the channels through which lower/higher aspirational targets embodied in competing regional plans may impact economic outcomes, and quantify the magnitude of some of the key positive spillovers from improving broadband infrastructure quality in rural eastern Ontario.

The basic question this report answers is whether the additional public sector investment required for the Gig model is worth it in terms of economic benefits?

To answer this question, this report analyses a number of key economic channels through which ultra-high speed/low latency fibre optic technologies generate economic value for consumers, service providers, and governments. We further quantify opportunity costs of poor broadband and value generation potential of the Gig model.

To assist regional stakeholders and upper-tier policymakers better understand economic benefits of future state model options EORN has outlined, we use a two-step methodology. As a first step, we compiled a range of data on the EORN technical models, economic attributes of the Region, and previous research on the economic impacts of ultra-high speed fibre access networks in Canada and internationally. We then use the baseline data to provide a range of models and estimates of future economic benefit flows the implementation of the EORN Gig plan can generate. Section 1 of the report provides an overview of the problem regional stakeholders are trying to address. Section 2 offers a global to local perspective on divergence in broadband infrastructure quality and its implications for economic development. Section 3 analyzes potential benefits of the future state regional models along several dimension, including:

- Demand side benefits: Consumer welfare/surplus gains
- Supply side benefits: Capital vs. operational cost minimization
- Examples of market failures as coordination failures in value capture:
    - a) Property values and municipal taxes
    - b) Telecommuters and emissions reductions
    - c) Home-based health care
- Employment/unemployment
- GDP growth and budget break even

In addition to quantitative estimates of opportunity costs of poor broadband/benefits of deploying high capacity fibre optic access networks in areas prone to private sector underinvestment and market failures, we incorporate potential implications of the shock caused by COVID in the analysis. Needless to say, considerable uncertainty about the implications and persistence of the COVID shock reduces the reliability of the estimates are provided in this report based on historical/pre-COVID data. Furthermore, estimates of the economic impacts of ultra-high-speed broadband based on data from other jurisdictions collected over the past decade before COVID may not necessarily be that relevant in a world where broadband connection reliability, quality of service, and affordability are vital for sustaining jobs and productivity at home, continuation of learning and education, accessing healthcare and other service, and generally remaining socially connected. Connectedness and connectivity are more valuable today, with the implication that historical baseline impact estimates used in this report may be significantly underestimating the potential for economic value generation from building high-quality broadband infrastructure residents and businesses in rural eastern Ontario demand.

The report is intended to provide high level estimates of some of the key variables that are likely to be impacted by the regional strategies EORN has developed. It is by no means exhaustive in its coverage of potential economic benefit spillovers associated with broadband infrastructure improvements.

**Findings**

Fixed capital expenditures cost estimates for building incrementally to the "basic service" model range from around $550 million to $1.6 billion for the full Gig model with "last mile" and fibre-to-the-premises (FTTP) builds to 95% of eastern Ontario (EORN models exclude the highest cost 5% of dwellings located in the very high cost/sparsely populated areas). While the fixed capital costs of deploying the full fibre optic Gig model is between 2 to 3 times higher than the basic service model, the Gig model will enable services with 20 times more downstream and 100 times more upstream bandwidth capacity. Consequently, the Gig model will have the ability to meet both current needs and accommodate future capacity scaling as demand grows at relatively low cost. Despite lower capital expenditure requirements of the basic service model, it is not necessarily cheaper than the Gig model when we consider future reinvestment and operating costs.

Regardless of the aspirational target, EOWC/EORN's analysis suggests that attracting complementary private sector investment needed to improve connectivity up to the basic vs. Gig target will require around two third public subsidies and/or co-investment in deploying fixed network assets. This translates to approximately $300 million (for the 50/10 model with optimistic cost assumption) to $1.2 billion (for the Gig model with moderate/reasonable cost assumptions) in public subsidies, which in turn EORN estimates will incentivise between $150 million (for basic service) to $400 million (for Gig model) in complementary private sector investments.

These baseline estimates were developed prior to the COVID shock and ongoing recession, which will likely have a further negative impact on the capacity and incentives of private telecom providers to invests in smaller towns, villages and hamlets, and rural areas with relatively low expected rate of return. Although COVID may further reduce private sector investment incentives in underserved areas, the pandemic has undoubtably had a strong positive impact on demand for reliable, more symmetric, low latency, Internet connectivity at home to work, go to school, access healthcare and other services, and sustain social interactions via network intensive multimedia applications. First generation broadband services may have been good enough for enabling first generation Internet applications such as email and simple web browsing, but with COVID this is no longer the case.

In the Gig model the planned investments will be primarily in middle and last mile fibre access network assets that have a long lifespan (20-30 + years). In the basic service model design, wireless equipment with a short lifespan makes up about one quarter of initial capital expenditures. This equipment generally needs to be replaced/upgraded every 3 to 7 years. Over the 20+ lifecycle of the fibre optic assets in the Gig model, the wireless equipment has to be replaced at least 4 times. Although the basic service model may look cheaper than the Gig model in terms of initial outlays, it will inevitably require further public subsidies in a few years to replace/upgrade the wireless equipment to sustain basic service quality levels it aims to deliver. The relatively low operational and capacity scaling costs of the full fibre Gig model, combined with its more pronounced impact on broadband service quality, mean that it will have a larger impact on economic value creation, employment growth, and thereby future government tax revenues. Our mid-range estimates suggest that with the Gig model initial public investment requirements can be fully recovered by upper-tier governments through taxes within 10 to 15 years after deployment. The basic service model is likely to require future public subsidies and unlikely to generate sufficient additional economic growth to enable tax recovery. The following table summarizes some of the key findings and mid-range estimates derived in this report.

**Summary Table: Findings and Economic Benefit Estimates**

| **Element** | **Findings/Estimates Note: Mid-range estimates** | **Comment/Explanation** |
|---|---|---|
| **Efficiency** | Gig model vastly superior in translating investment into network improvements | ~2 times CAPEX in Gig model will translate into 20x more capacity downstream and 100x more capacity upstream compared to basic service model |
| **Equity** | Gig model vastly superior as extends ultra-high speed, low latency fibre access to 95%fibre | Basic service model aims to achieve a minimum standard that may not be adequate anymore, while the Gig model designed to deliver services that are comparable in quality to those available in large urban centres |
| **Current vs. future investment requirements** | Over 4 to 6 equipment refresh cycles, the costs of the Gig vs. basic service models will be comparable | CAPEX in Gig model mainly in fibre with a very long lifespan vs. basic service model where a large portion of CAPEX in wireless equipment that needs to be replaced every 3 to 7 years (we assume 5 years for the analysis here) |
| **Affordability** | Capacity constraints under the basic service model will lead to higher quality adjusted prices. Gig model cheap to scale as demand grows in the future | Data caps, overage fees, and/or throttling of speeds remain common in the mobile and fixed wireless broadband markets, while FTTP deployments will enable unlimited data services with little service quality degradation |

| Summary Table: Findings and Economic Benefit Estimates | | |
|---|---|---|
| | | |
| **Quality of Service (QoS)/reliability** | The fibre portions of both plans have the capacity to deliver high availability/quality services | Fibre more reliable than copper and wireless, particularly in the spring when the trees turn green. It is not clear if the wireless portion of the basic service model will enable delivery of broadband services that will meet CRTC latency and other minimum QoS standards |
| **Synergies with 5G** | The basic service model does not expand “deep fibre” very much into rural areas | Gig model can help reduce the costs of deploying “small cell”/5G networks facing wireless service providers, municipalities, and small underserved communities. |
| **Investment incentives** | Subsidizing low capital intensity wireless will reduce take up rates for high-quality technologies later | Adopting the wireless portion of the basic service model will undermine the long-term case for deploying fibre access networks and decommission decades old copper telephone plants |
| **Complementarities in fixed/wireless service quality** | Accelerating fibre deployments will improve wireless service quality in the Region | Expanding access to ultra-high speed/low latency fibre networks allows high demand users to switch to the higher quality network, reducing the load on congestion prone wireless broadband networks on the rural edges of the network |
| **Complementarities with EORN cell gap project** | Macro cell design in basic service model may help mitigate cellular coverage and capacity gaps | EORN’s cellular project is already working to address coverage and capacity gaps in 4G/LTE macro cell infrastructure, the marginal value added from the 50/10 basic service design limited relative to the Gig design that would enable microcell/5G network diffusion in small towns/hamlets remains unclear |
| **Copper decommissioning** | Gig model would allow for extensive copper decommissioning and cost reduction for incumbent telecom provider in the long run | Universal service obligations on telephone and low speed data access require incumbents to maintain decades old and expensive to maintain copper plants. Unless they have first deployed fibre access networks in a particular area, CRTC is unlikely to allow incumbents to decommission copper plants |
| **Consumer welfare** | $1.3 billion over 10 years post deployment with Gig model | Mid-range consumer surplus gains from access to ultra-high speed/low latency/symmetric fibre vs. legacy DSL/cable: $1000 per year per subscriber; at 50% FTTP take up in region at current market prices for Gig services in urban |
| **Consumer savings from price commitments** | Additional $650 million over 10 yeas post deployment with Gig model | Assuming EORN can obtain Gig pricing discount commitments of $40 per month relative to current market prices of $120 for Gig services (where available) from its service provider partners in exchange for public capital expenditure subsidies |

| Summary Table: Findings and Economic Benefit Estimates | | |
|---|---|---|
| **Operational cost reductions from fibre vs. copper** | $13 million per year at 50% take-up ramping up to a total of $200 million over 10 years | Extrapolating from Bell Aliant cost reductions from transitioning customers from copper to FTTP at ~ $100 per year per subscriber |
| **Equipment refresh** | $550 million more required over 20 years/4 equipment refresh cycles for basic vs. Gig model ($3700 per household) | Mainly due to the high proportion of wireless equipment in the basic service model, which needs to be replaced every 3 to 7 years. Long term capital cost requirements of both models broadly comparable over a 20 to 30 year time horizon/expected life of fibre optic assets |
| **Emissions** | Gig model significantly less power consumption/pollution | Controlling for data consumption levels, wireless broadband generally has 10 time the power consumption of wired; fibre has about 1/5 of power consumption of legacy DSL and 1/10 of coaxial cable. Particularly relevant differentiator given rapid growth in data demand at home caused by COVID |
| **Property values** | 3% growth in median property values, or $7500 per home | Per home benefits in terms of property values higher than EORN's estimated costs of FTTP deployment per home (between $4000-$6000 depending on the model). With COVID, it will be very hard to sell houses with sub-par connectivity and people will value homes with reliable connectivity relatively more. The FTTP premium on property values might be substantially higher than our mid-range estimates. Our high end estimate of an increase of $17,500 per home might be more realistic at this point than the mid-range estimates |
| **Municipal property taxes** | $20 million per year/$200 in 10 years | Assuming a property value tax rate of 1%. Note that there some variation around this rate at the local level. Can materialize post deployment and once the FTTP premium is incorporated in taxable property value assessments. Amount not sufficient to cover/finance deployment costs locally. Explains why upper-tier financial support required from broader tax revenue streams |
| **Telecommuting: Private benefits** | $400 million annual cost avoidance for rural telecommuters in the region | At 20% telecommuting rate post COVID and cost avoidance of ~$8,000 per year per rural telecommuter, based on estimates from Southwestern Ontario and Halton Region. The potential private benefit higher than EORN's estimated costs of fibre deployment per household ($4000-$6000) |
| **Telecommuting: Public benefits** | 200 kg reduction in per capita CO2 emissions | |
| **Home-based healthcare** | $170 million (4%) reduction in the costs of healthcare delivery in the Region | Based on estimates from case studies on FTTP and advanced healthcare application deployments in rural Sweden. This does not include benefits in terms of potential benefits from quality improvement and other benefits associated with remote healthcare deliver in the time of COVID |
| **Employment and taxes: Deployment** | 12,000 jobs sustained/created with | Deployment phase employment and tax recovery from basic service model lower proportionally to the lower level of |

| Summary Table: Findings and Economic Benefit Estimates | | |
|---|---|---|
| **phase (first 3 to 5 years)** | Gig model; 3000 in region<br>$500 million in upper tier tax recover for construction spending | investment and fibre construction in relatively high cost areas. Based on industry specific and generic infrastructure multiplier estimates. Note that fiscal multipliers tent to be higher in times of recession/depression where there is substantive slack. |
| **Employment and taxes:<br>Long term (5-10 years post deployment)** | 4000 additional local jobs from Gig project; reduction of unemployment by 3.5%; $27 million annually in additional taxes | Based on previous estimates from Bell Aliant FTTP deployments and diffusion of FTTP in French municipalities, scaled to the size of the labour force in target area |
| **GDP growth and tax recovery** | Short to medium term:<br>-GDP impact: $1.4 billion<br>-Tax revenue: $450 million<br><br>Medium to long term:<br>-GDP impact: $2.4 billion<br>-Tax impact: $800 million | Using generic Ontario public infrastructure spending multiplier estimates from previous studies compiled for the Ontario Government to assess previous programs and as baselines for the development of the Ontario's Long Term Infrastructure Plan (LTIP, 2017). |
| **Medium to long term GDP growth and total tax recovery (5 to 10 years post deployment)** | $300 million increase in GDP level in rural eastern Ontario; $100 million annual increase in tax revenue from the region. | Based on literature review of estimated elasticities of ultra-high speed/fibre broadband diffusion around the world, scaled to regional characteristics. Impacts to materialize post deployment, take up, and productivity growth phase. Post deployment and ramp up in take up. 10 year total GDP impact up to $3 billion; tax revenue impact up to $1 billion. |

Throughout the analysis, we have tried to cross-check and validate estimates above with a variety of methods and by applying a range of reasonable estimates from previous literature to the case of rural eastern Ontario. Past experience may not be relevant for the future, particularly in a time when the structure of the economy, work, and life balance is responding to the unprecedented shock caused by COVID. Some of the different methods that we use here help triangulate our estimates and generate broadly consistent results, which helps validate some of the key benefit estimates. In particular, from a macro economic perspective both generic Ontario public infrastructure spending multipliers and fibre to GDP specific elasticities from previous research suggest that in the medium to longer term (i.e. post construction/deployment) the EORN Gig project is likely to increase GDP in rural eastern Ontario between $2.4 and $3 billion, generating additional tax revenues for the Ontario and Federal governments between $800 to $1 billion. When we add estimated short-term tax revenues associated with the construction/deployment phase of the project (estimated to be between $450 to $500 million) to the long term estimates, the future value of additional government revenue from GDP growth will start to exceed the initial subsidy requirements of $1.2 billion for the EORN Gig project.

Key microeconomic sources of positive spillovers in the EORN Gig model include consumer welfare improvements, property value growth, operational efficiencies and costs savings for service providers, enhanced telecommuting capacity, and potentially significant healthcare cost savings as virtual healthcare delivery becomes more acceptable and common with the COVID shock. We have not looked at benefits of better broadband for enabling education or other potentially important channels through which reliable broadband adds economic value and promotes equality of opportunity for people that live and work in underserved areas of rural eastern Ontario. Furthermore, we do not explore the potential for reductions/growth in the Region's population that may be associated with sub-par/high-quality broadband infrastructure. Despite the narrow focus of the analysis, our estimates of economic benefits are sufficient in magnitude and reliability to allow us to conclude that the economic benefits of the Gig model will be larger than the estimated capital costs in the medium to long term.

**Recommendations**

The projected economic benefits of the EORN Gig project clearly outweigh its costs in terms of public fixed costs subsidies that its implementation will require, while lower operational costs of fibre optic access networks will enhance the technical and financial sustainability of this strategy. In addition to lower speeds and hard to resolve reliability issues (i.e. in the spring when leaves grow), the large wireless component in the basic service model will require recurring investments in wireless equipment with a short lifespan. This will threaten the quality of service available to people as demand grows on congestion prone and hard to scale wireless technologies, as well as the financial viability the EORN basic service model without additional public subsidies in the future.

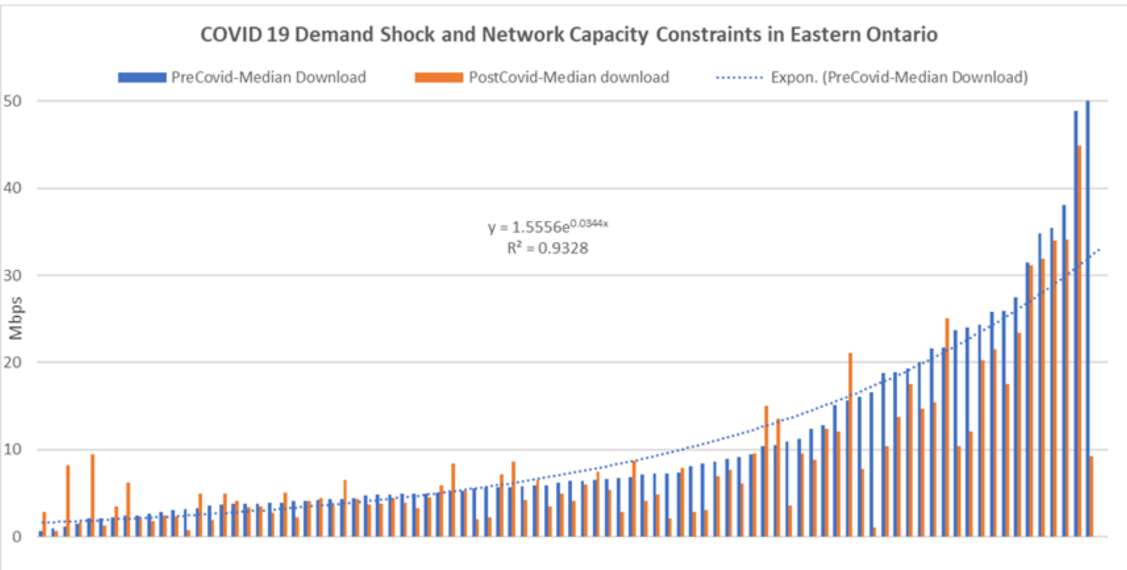
Given extensive evidence on positive private and public benefits of deploying ultra-high speed/low latency fibre optic access network, larger short-term economic stimulus impact, and likelihood of tax recovery in the medium to longer term, we recommend adopting the EORN Gig model over the basic service model. If fiscal constraints and other priorities limit the capacity of upper tier governments to respond to demand for equitable access to high-quality broadband in rural eastern Ontario, then we recommend funding only the wired portion of the basic service model and only long-lived assets in the wireless portion (e.g. middle and last mile fibre, carrier-grade Points of Presence (PoP), "macro cell" towers). Focusing scarce public subsidies on assets with a long lifespan that can be shared by multiple wireless providers can attract complementary private sector expenditures on wireless equipment. Expanding fibre access footprint as fast as possible within the Region will have the additional benefit of improving wireless service quality by allowing more high-demand users to switch to fibre where available, taking some of the load off oversubscribed wireless networks on the rural edges.

Given that large infrastructure providers in the Region are already accelerating their investments in wireless access technologies with relatively low fixed capital expenditure requirements by leveraging incentives in the Federal budget, it will be more efficient for the public sector to support these investments by focusing scarce public subsidies on long lived assets such as towers and fibre. Attracting complementary private sector investments for deploying "deep fibre" networks with a long lifespan will be the key to ensuring that the economic benefits estimated in this report, as well as others we have not analyzed here, will materialize. In addition to enabling connectivity at capacity and reliability standards that are comparable to Canada's urban cores and full tax revenue recovery in 10 to 15 years, the EORN Gig model is superior to the basic service model because it would allow legacy copper plant decommissioning and reducing the costs of deploying next generation "small cell"/5G wireless broadband facing service providers in small towns, hamlets, and rural areas where they would otherwise have little incentive to invest.

# Economic Benefits of Investing in Basic vs. Gigabit Broadband Infrastructure in Rural Eastern Ontario

## 1. Introduction

**Context:** Demand for reliable Internet connectivity has stimulated significant private investment in deploying ultra-high capacity fibre-optic broadband networks in Canada's urban centres and larger towns. Despite some improvements in rural connectivity over the past few years, private sector incentives to expand access to relatively high-speed cable and fibre-based broadband access technologies has proven to be limited in small towns, hamlets, and remote communities in all regions of Canada. The consequence is a growing rural-urban digital divide in broadband service quality and affordability. All levels of government have been searching for viable solutions to counteract market failures and promote private investment incentives in rural broadband, with varying degrees of success.




Median download speeds in 90 municipal entities/test aggregation locations in Eastern Ontario; first quarter in 2020 vs post COVID lockdowns up to end of June 2020; Source: M-Lab

**COVID demand shock:** The COVID 19 pandemic has demonstrated the vital nature of reliable and affordable broadband Internet connectivity to social and economic participation of individuals, productivity and employment, and delivery of other essential public and private services such as education and healthcare. Rapid growth in demand for network resources caused by the pandemic has pierced the myth that broadband infrastructure quality in rural Canada is, more or less, good enough. In addition to relatively low download speeds, the pandemic has highlighted the limitations of wireless and satellite-based services in terms of upload speeds, latency/Quality of Service (QoS), and affordability (i.e. two (or three part) usage-based pricing/throttling on capacity constrained wireless vs. unlimited data on wired networks).

**Broadband infrastructure as fiscal stimulus:** In response to demand for better broadband, all levels of government are exploring how they can help improve connectivity in relatively high cost/low revenue areas where the business case to invest in wireless network capacity and/or scalable wireline fibre access networks is lacking. In addition to promoting supply to meet demand for better connectivity, public investments in construction of broadband networks can serve as an impactful fiscal stimulus to counteract the recession, absorb slack, and help sustain employment. Public broadband infrastructure investments played a part in fiscal measures adopted subsequent to the last recession in the late 2000s.[2] A number of countries that now have extensive fibre access networks started the process back then as governments accelerated investments in broadband infrastructure to promote economic recovery. The role public broadband infrastructure investments can play purely as an element of the broader fiscal stimulus against the COVID recession (depression?) is worth considering in support of economic recovery.[3]

**Regional coordination and solutions:** As part of their response to the COVID pandemic, the Eastern Ontario Wardens' Caucus (EOWC) and the Eastern Ontario Leadership Council (EOLC) have prioritized improving the quality and affordability broadband Internet connectivity in underserved areas of the Region. To achieve this objective, the eastern Ontario Regional Network (EORN) has developed two high-level technical strategies that aim to enhance broadband infrastructure capacity and service quality in underserved areas (i.e. those areas where services that meet the basic service speed targets defined by the Canadian Radio-television and Telecommunication Commission (CRTC) are not available to residents and businesses). Future state scenarios EOWC/EORN have outlined range from a lower cost option designed to improve regional network capacity to deliver speeds that satisfy CRTC's "basic service" aspirational speed targets of 50/10 Mbps (with a combination of wireless and wired/fibre access technologies), as well as more ambitious proposals that would expand access to ultra-high capacity/low latency fibre-to-the-premises (FTTP) networks to 95% of Region (hence the "basic service" vs. "Gig" models).

**Objective and scope**: Having costed the options, EOWC/EORN aim to better understand how the two models may differ in terms of their potential economic benefits in order to assess against the estimated fixed capital cost differences. This report analyzes the two distinct high-level technical models aimed at improving broadband connectivity in rural areas of eastern Ontario. The objective of the report is to provide high level estimates of potential positive spillover value streams (i.e. externalities) from improving connectivity to support regional and upper-tier policymakers in their decision making. We do not consider other possible strategies that may be available, nor provide an exhaustive accounting of potential channels through which better connectivity can benefit residents and businesses in the Region. As detailed in the report, the

[2] OECD (2009). The Role of Communication Infrastructure Investment in Economic Recovery. http://www.oecd.org/internet/broadband/42799709.pdf
[3] OECD (2020). Policy Implications of the Coronavirus for Rural Development. http://www.oecd.org/coronavirus/policy-responses/policy-implications-of-coronavirus-crisis-for-rural-development-6b9d189a/

quantum of benefits along the channels of value creation analyzed here is sufficient to demonstrate that the economic benefits of paying the higher fixed capital costs of the Gig model today substantially outweigh its higher subsidy requirements. Based on what we believe are reasonable assumptions given available information and economic uncertainties around COVID, we provide a range of estimates of the value deploying ultra-high capacity/2$^{nd}$ generation broadband can generate and how long it might take for upper-tier governments to recover infrastructure spending on broadband from increased tax revenues from residents and businesses in eastern Ontario.

**Methodology**: Over the past decade, a large research literature has evolved that tries to evaluate the empirical linkages between expansion of high-speed access (e.g. over-dial up) and higher speed connectivity on the one hand, and economic outcome indicators on the other. Examples of economic variables associated with better broadband include, GDP, productivity growth, employment/unemployment, wages, property values, healthcare spending etc. Overall, studies find a robust positive association indicators of broadband infrastructure quality and FTTP deployment on economic outcome indicators. Our review of the research suggests there is little agreement about the magnitude of these impacts, or the direction of causality between broadband quality and economic variables. Higher income countries, regions, and neighbourhoods tend to attract more private investment in broadband infrastructure, and also tend to have the capacity to gain more in terms of productivity growth, employment and educational opportunities, e-commerce models etc. that access to high-quality broadband connectivity enables (i.e. "the rich get richer" effect). On the other hand, access to better broadband provides an opportunity for people and communities now falling behind to increase productivity and exploit innovation enhancing opportunities to "catch up" (i.e. "advantage of backwardness" effect).

This report builds on previous macro and microeconomic research evaluating empirical associations between broadband infrastructure quality and economic outcome indicators to assess channels and estimate magnitudes of economic benefits that may flow from the EORN's basic service vs. Gig broadband improvement models. We explore both supply and demand size implications of the two technical approaches, and analyze a range of effects that achieving the lower/higher standards may have on regional economic development outcomes. Unless stated otherwise as might be relevant, we draw inferences and base our conclusions based on what we believe are reasonable mid-range estimates of particular sources of value generation and economic impact.

**Uncertainty and limitations:** The scope for collecting new economic and social data from eastern Ontario for this report has been limited given the required timelines of this project and prioritization of the Gig project by EOWC post COVID. The report will therefore rely primarily on available data compiled by EORN, EOWC, EOLC, baseline estimates of elasticities/correlations between broadband speed/quality and economic outcome indicators from previous research, as well as other relevant third party data that helps capture differences in expected economic benefits streams of proposed initiatives.

The analysis is by no means comprehensive and estimates of economic impacts provided reflect a high level of uncertainty. This is particularly the case given the COVID shock to demand and supply is likely to make historical economic data highly unreliable as a basis for predicting future trends. Furthermore, estimates of the impact of broadband improvement and fibre network deployment effects from the past and/or other regions in Canada and abroad may not necessarily be relevant given unique local conditions in eastern Ontario. To mitigate against the risks of errors, we have tried to simplify the analysis as much as possible to make it tractable, consider a range of scenarios, and triangulate using different analytical approaches to ensure the validity of overall results.

While we focus on mid-range scenarios for the purposes of this report and drawing inferences for project selection and funding, with COVID residents and communities without access to reliable broadband are likely to fall rapidly behind in their efforts to adjust and rebuild, retain and attract families and businesses, and deliver basic public services such as education and healthcare. At the same time, COVID is going to make private sector investors less likely to invest scarce capital in capacity upgrades in rural areas and small communities with low (or potentially negative) expected rate of return. The mid-range estimates based on historical/pre-COVID impact assessments and economic baseline data might therefore represent a gross underestimate of the opportunity cost of slow and unreliable broadband and the benefits of deploying ultra-high capacity and long-lasting fibre access networks throughout the Region.

**Local variations and future analysis:** There are likely material variations in the capacity and incentives of people and businesses in particular communities in eastern Ontario to leverage better broadband, and therefore grow productivity and incomes. We do not analyze potential impacts of in-region variations on local capacity to benefit from improved broadband in this report. The key objective is to better understand the differences between the two future state models at a macroscopic regional level and provide a range of reasonable estimates of public and private benefits that assist policymakers evaluate against capital costs differences of the two models. With reliable disaggregated data that helps benchmark and evaluate the linkages between supply side quality improvements and economic outcomes at the local level, it would be feasible to evaluate potential local variations in benefits (e.g. within particular EOWC/EOLC counties/municipalities).

**Projection**: The pandemic will have a significant negative impact on the quality and affordability of services in areas that are already considered underserved (i.e. that lack access to upgraded cable (DOCSIS 3.1) and/or fibre wireline/FTTP).

**Projection:** The COVID recession (depression) will accentuate the positive/negative impact of good/bad broadband on individual and aggregated economic outcomes at local, and regional levels.

**Economic benefits vs. loss minimization:** Put more bluntly, with COVID and without sufficiently reliable Internet access one can easily lose their job as resource constrained employers are naturally inclined to decommission those employees who cannot work relatively efficiently, for whatever reason. The prospects for education and delivery of other public services without reliable Internet are also stark if the pandemic becomes endemic. Expanding reliable and affordable access to high-quality/low latency broadband services that allows multiple people in a household to use multiple data intensive services simultaneously is vital to their ability to survive the crisis without too much damage to current incomes and/or intellectual capital accumulation of young people that ultimately drives future prosperity.

## 2. Global to Local Perspectives on Broadband Divergence and Economic Development

In high income countries such as Canada, access to some form of "high-speed" broadband Internet connectivity is near ubiquitous. The quality and affordability of broadband services can vary significantly across countries and within regional markets. Expanding access to high-quality broadband in rural areas and into remote communities still remains a challenge, even in some of the leading countries in Northern Europe and East Asia with relatively high levels of fibre penetration and relatively shorter distances between communities than Canada or the United States. This section provides an overview of global and local trends in the development of broadband infrastructure and economic implications of divergence in broadband infrastructure quality.

Starting from a luxury accessible to a few "early adopters" in the 1990s, high-speed (broadband) Internet connectivity has become a necessity for social and economic participation, improving business productivity, delivering public services, and building "intelligent/smart" communities. An as essential social and business input in our information society, disparities in access to reliable and affordable connectivity can accentuate existing socio-economic barriers across and within communities. Quality of service and affordability of access to multipurpose broadband networks represents key constraints on the ability of individuals and businesses to use Internet applications and services that meet their diverse needs. From an economic perspective, slow and expensive broadband has both distributional and efficiency implications.[4]

### 2.1. Digital Inclusivity

In places where high-quality broadband is available, those who cannot afford to pay for premium services are disadvantaged relative to those with higher incomes that can. In relatively high cost/low return rural areas where private sector incentives to provision capacity and deploy new technologies can be limited (or non-existent), even those who can afford to pay often have little option but to rely on old and slow broadband technologies (e.g. DSL, wireless, satellite). This increasingly creates demand for public policies aimed at promoting universal access to "high-quality" broadband Internet connectivity, at national, regional, and local level.[5]

Promoting digital inclusivity through public policy may not be necessary everywhere. In some communities', higher incomes and/or lower costs due to high population density, can create strong

[4] Rajabiun, R., Ellis, D., & Middleton, C. (2016). Affordability of Communications Services. Report commissioned by the Canadian Radio-television and Telecommunications Commission. Available at: http://www.broadbandresearch.ca/ourresearch/lit-review-for-crtc-2016-affordability-rajabiun-ellis-middleton.pdf

[5] Rajabiun, R. (2017). The Rise of Broadband as an Essential Utility and Emergent Concepts in Universal Access in Advanced Economies: Perspectives from Canada. Available at: https://www.econstor.eu/handle/10419/169494

(or at least adequate) private sector incentives to deploy competing high-speed networks and invest in added capacity as demand for bandwidth grows with time and new over-the-top (OTT) applications. Even in low cost urban centres, private sector incentives are not always optimal without public sector initiatives that complement private sector deployments of advanced broadband technologies and help "crowd in" efficient private investment.[6] In rural areas and remote communities, older and lower income urban areas, the business case to scale network capacity as demand grows with new technologies is not always viable without some form of public subsidy, demand aggregation, and/or cost reduction measures.

In countries that are further along in the transition from old copper telephone infrastructure to advanced fibre networks, consumers tend to benefit from lower quality adjusted prices of broadband services.[7] This is because ultra-high capacity fibre networks limit the need and incentives of telecom providers to ration scarce bandwidth in the face of growing demand by users for more bandwidth intensive applications, scaling their networks at lower cost than is feasible on old legacy copper/DSL, coaxial cable, or wireless broadband plants. Deploying scalable fibre technologies might have larger fixed costs than what is proverbially called "sweating the copper" strategies in the telecom industry. However, deploying fibre access networks (or potentially ultra-high capacity hybrid fibre/5G wireless networks in the future) appears to be the primary long-term solution for making Internet access more affordable by expanding capacity exponentially.[8]

As documented in the figure bellow using comparable international subscription pricing data from the European Commission, Canada and the U.S. have some of the highest fixed broadband prices in advanced economies; whereas countries such as Japan and Korea where scalable fibre infrastructure is widespread, consumers tend to benefit from substantially lower prices.[9]

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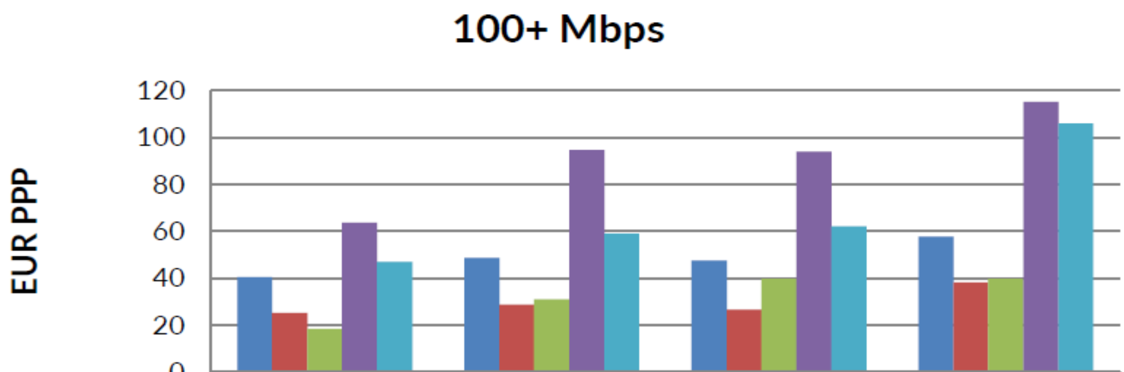
[6] Wilson, K. (2017). Does public competition crowd out private investment? Evidence from municipal provision of internet access. NET Institute Working Paper 16-16. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2848569
Nevo, A., Turner, J. L., & Williams, J. W. (2016). Usage-Based Pricing and Demand for Residential Broadband. Econometrica, 84(2), 411-443. Available at: https://www.nber.org/papers/w21321.pdf

[7] Bischof, Z. S., Bustamante, F. E., & Stanojevic, R. (2014, November). Need, want, can afford: Broadband markets and the behavior of users. In *Proceedings of the 2014 Conference on Internet Measurement Conference* (pp. 73-86). ACM. Available at: http://zbischof.com/publications/papers/imc14-bischof.pdf

[8] Rajabiun, R., Ellis, D., & Middleton, C. (2016). Affordability of Communications Services. Report commissioned by the Canadian Radio-television and Telecommunications Commission. Available at: http://www.broadbandresearch.ca/ourresearch/lit-review-for-crtc-2016-affordability-rajabiun-ellis-middleton.pdf

[9] https://ec.europa.eu/digital-single-market/en/news/fixed-broadband-prices-europe-2016




| | Standalone | Double play with Tel | Double play with TV | Triple play |
|---|---|---|---|---|
| EU28 | 40,36 | 48,74 | 47,58 | 57,60 |
| Japan | 25,10 | 28,72 | 26,56 | 38,14 |
| South Korea | 18,41 | 31,01 | 39,73 | 39,73 |
| USA | 63,66 | 94,59 | 93,91 | 115,09 |
| Canada | 46,88 | 59,00 | 62,00 | 106,00 |

*Broadband Prices in Advanced Economies.*
*Source: European Commission, 2016*

The link between the diffusion of high-capacity fibre optic networks and affordability of basic telecommunications services is particularly important in understanding demand for public policy to promote technological change in rural communities. In areas with upgraded cable and/or fibre access networks, there are stronger competitive forces at play to offer unlimited service packages without significant risk of quality of service degradation when demand for network resources is high. On capacity constrained satellite, wireless, and legacy copper/DSL pants, service providers can have incentives to use two or three part pricing schemes to monetize limited capacity they have in place. Data caps and overage fees represent a key threat to the ability of low income users in rural communities that have little option but to rely on wireless to scale their demand for network intensive applications and services.

With COVID, network intensive multimedia and cloud-based have become a basic necessity of life, which puts low income vulnerable residents in rural communities at further disadvantage. Although fear of overage charges may have been manageable to some degree a few years ago as some basic Internet applications do not require high bandwidth and large data transfers (e.g. email, simple web browsing), a wide range of other over-the-top communications and multimedia applications can be data intensive. Constraints posed by data caps, throttling, and overage fees are a particular concern during the time of COVID as accessing more data intensive applications has become vital to people's work, education, and communications. While service providers have suspended data caps on fixed broadband plans in response to COVID, they remain effective on wireless plans and are reportedly “making a killing” from data overage charges people have to pay.[10]

**Projection**: Due to existing network capacity constraints and pricing models, demand growth will accentuate affordability as a barrier to social and economic participation of low income rural users that have little option but to rely on data capped wireless and satellite broadband services. Improving quality adjusted prices will require diffusion of fibre middle and last mile networks deeper into rural areas and small communities. In the medium to long term, emergence of low earth orbit (LEO) broadband satellite constellations may improve the affordability of broadband access available to very users on the very remote edges of the network.[11]

**Projection**: Countries and communities that fail to find innovative strategies for promoting technological change from legacy copper to high-capacity fibre access and small cell/5G networks will experience higher inequality and lower productivity growth.

### 2.2. Economic Development and Technological Change

The global experience with the development of fixed broadband Internet infrastructure illustrates that improved network quality and affordability have a positive and sustained impact on Information and Communication Technology (ICT) intensification, productivity growth, and various other indicators of economic development.[12] Evidence suggests efficiency enhancing effects of reliable broadband networks required to utilize more advanced business applications is particularly pronounced in Small and Medium Size Enterprises (SME).[13] In addition to making it

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[10] Techdirt. Canadian Wireless Carriers Making A Killing During COVID-19, Won't Remove Caps 'For Safety'. May 15,2020. https://www.techdirt.com/articles/20200512/07570544482/canadian-wireless-carriers-making-killing-during-covid-19-wont-remove-caps-safety.shtml

[11] For an analysis of approaches by different LEO proponents see: del Portillo, I., Cameron, B. G., & Crawley, E. F. (2019). A technical comparison of three low earth orbit satellite constellation systems to provide global broadband. Acta Astronautica, 159, 123-135. http://systemarchitect.mit.edu/docs/delportillo18b.pdf

[12] Czernich, N., O. Falck, T. Kretschmer, and L. Woessmann (2011). Broadband Infrastructure and Economic Growth. *The Economic Journal* 121. Lüdering, J. (2016). Low latency internet and economic growth: A simultaneous approach. TPRC44. Ayanso, A., & Lertwachara, K. (2015). An analytics approach to exploring the link between ICT development and affordability. *Government Information Quarterly*, *32*(4). Ivus, O., & Boland, M. (2015). The Employment and Wage Impact of Broadband Deployment in Canada. *Canadian Journal of Economics*. Pant, L. P., & Hambly Odame. H. (2014). Outcome Analysis of Rural Broadband Programs: A study of rural small businesses and community organizations served by phase one of the Eastern Ontario Regional Network–a high speed Internet initiative. The Monieson Centre, Queen's School of Business, Queen's University, Kingston, Ontario.

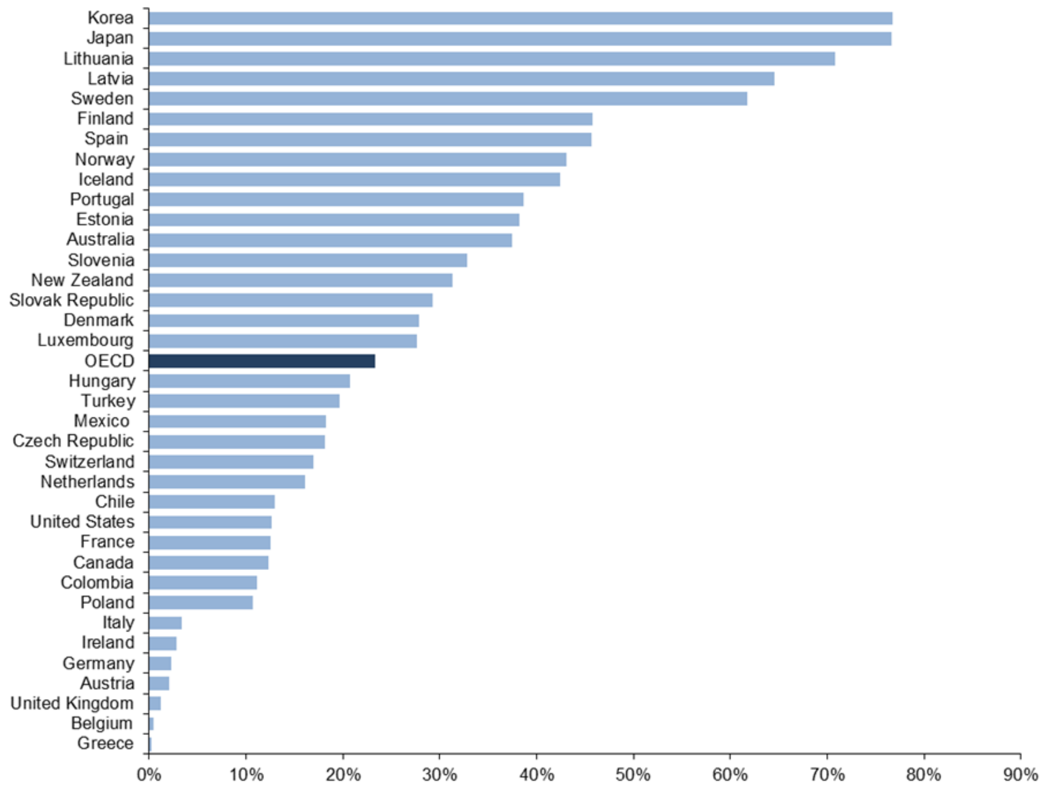
[13] Colombo, M. G., Croce, A., & Grilli, L. (2013). ICT services and small businesses’ productivity gains: An analysis of the adoption of broadband Internet technology. Information Economics and Policy, 25(3), 171-189. Bertschek, I., & Niebel, T. (2016). Mobile and more productive? Firm-level evidence on the productivity effects of mobile internet use. Telecommunications Policy. Falk, M., & Hagsten, E. (2015). E-commerce trends and impacts across Europe. International Journal of Production Economics, 170, 357-369.

possible to rely on various business applications in the "cloud", high quality broadband infrastructure is required for enabling the adoption of disruptive technologies that are critical for long term development of rural and urban communities alike.[14]

Policymakers at various levels of government increasingly recognize broadband Internet infrastructure as a critical component of the broader social and business infrastructure they need to support in order to make their communities attractive in a world of mobile capital, achieve efficiencies in business and public service delivery. This also fosters a competitive climate for the development of a diverse knowledge and technology intensive economy. However, Canada has fallen behind significantly in the transition to fibre compared to other advanced economies. As documented in the figure below, penetrations rates of fibre-to-the-premises (FTTP) broadband subscriptions are about half of the average for OECD countries (~12% vs. 25%), and well below leading countries in East Asia and Norther Europe.[15]

In terms of coverage, according to most recent data from the CRTC, FTTP based services are available to just below half of Canadian households (~ 45%).[16] Given that more than 80% of the Canadian population live in urban areas, this means there is still a long way to go before providers expand fibre to all urban, suburban, and the potentially rural areas. Waiting for them to do so involves opportunity costs in terms of the quality of life, independent living, property taxes, and economic development, that are hard to measure and monetize via market mechanisms.

[14] For an overview of applications and technologies with a emphasis on the needs of SMEs in rural communities, see: https://www.eorn.ca/en/resources/eBusiness-Tool-Kit/EORN_eBusinessToolKit2016_Web-FINAL.pdf
[15] https://www.oecd.org/sti/broadband/broadband-statistics/
[16] CRTC, Communications Monitoring Report, 2019: https://crtc.gc.ca/pubs/cmr2019-en.pdf




*Fibre-to-the-premises (FTTP) Penetration (Percentage of total broadband subscriptions; Source: OECD, 2017*

A notable exception to Canada's poor performance in terms of FTTP deployment is the experience in Atlantic Canada where Bell Aliant chose to take fibre closer to end users with a fibre-to-the-premises (FTTP) strategy starting a decade ago.[17] In contrast to the decision by Bell proper in Ontario and Quebec, and Telus in Alberta and British Columbia, to adopt a cheaper fibre-to-the-node (FTTN) + copper/DSL last mile deployment strategies that allows for "sweating the copper" over a longer period, Bell Aliant at the time decided that the benefits of deploying FTTP outweigh its costs given the age and long loop lengths of its copper plants in Atlantic Canada.

Unfortunately, sub-national data on fibre deployments is not readily available as it is considered confidential and not published by federal regulatory authorities. This lack of information puts lower levels of government at a distinct disadvantage in developing broadband strategies that maximize value for money and leads to inefficient duplication. This issue has been recently raised by the Federation of Canadian Municipalities (FCM) in its submission to the CRTC regarding barriers to rural broadband deployment at the federal level and is currently under consideration by

[17] RBC Capital Markets, Telecom Scenario Report. August 2015.

the federal telecom regulator.[18] Enhanced private cooperation with local governments and regional entities such as EOWC/EOLC/EORN regarding their existing networks and terms of access can be critical for cost minimization in deploying the regional strategy and ensuring that scarce public funds are targeted more efficiently in areas that are further behind.

### 2.3. Broadband Divergence, Provider Incentives, and the Role of Government

Research on the evolution of broadband networks in Canada and internationally documents a growing gap among and within countries in the quality/speed of Internet access services telecommunications providers deliver/consumers experience.[19] Telecommunications service providers' (TSPs) incentives to invest in network capacity and/or new technologies can be particularly weak in some areas, for instance rural regions, small and remote communities, as well as lower income neighborhoods in urban centres.[20] The growing divide in broadband infrastructure quality has a variety of causes, including costs/expected revenues from investments in particular areas (i.e. geospatial dimension), technological endowments and organizational choices of service providers (strategic choices), and the design of public policies and regulations that shape private sector investment and competition incentives to invest in broadband network capacity and fibre access technologies.[21] In broad terms, consumers experience substantially higher speeds and pay lower prices in countries where a combination of public policy leadership and private sector innovation has accelerated the decommissioning of sunset copper-based technologies and deployment of ultra-high capacity fibre to end users.

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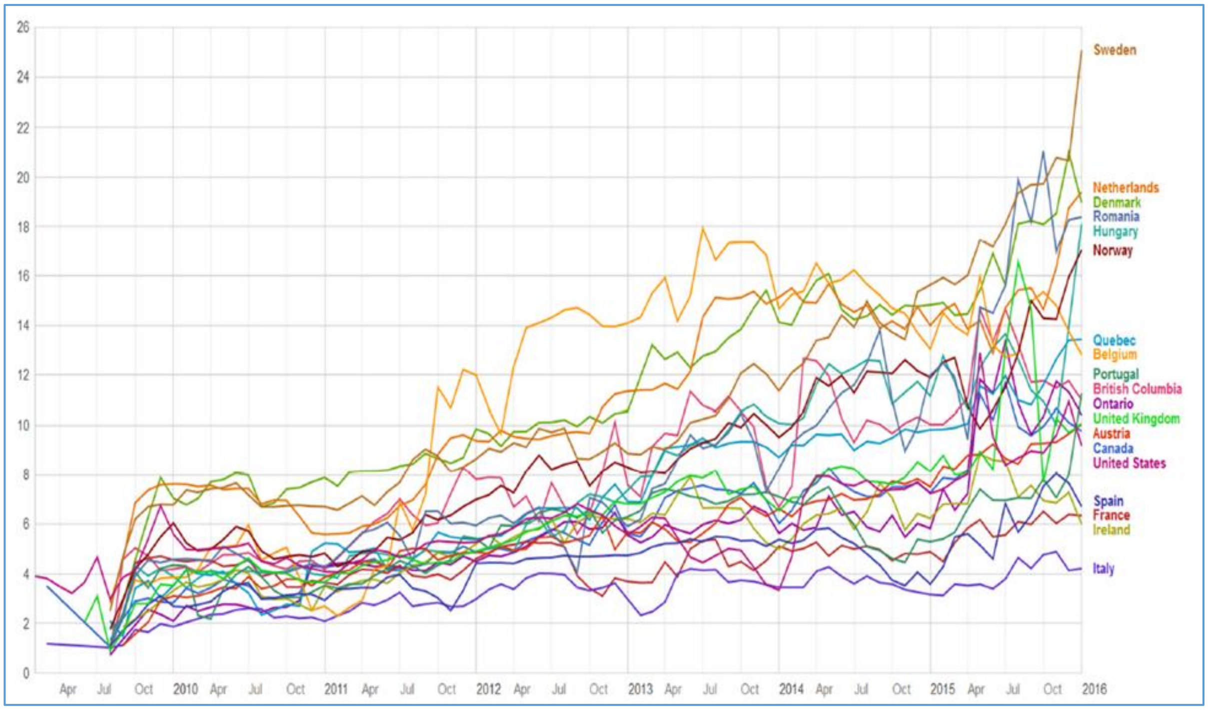
[18] FCM first submission to Telecom Notice of Consultation CRTC 2019-406. https://services.crtc.gc.ca/pub/ListeInterventionList/Documents.aspx?ID=292582&en=2019-406&dt=i&lang=e&S=C&PA=t&PT=nc&PST=a

[19] Rajabiun, R., & Middleton, C. (2017). Regulatory Federalism and Broadband Divergence: Implications of Invoking Europe in the Making of Canadian Telecom Policy. Intereconomics, 52(4), 217-225. Available at: https://www.ceps.eu/system/files/IEForum42017_5.pdf

[20] Rajabiun R. (2016). State of Broadband Internet Infrastructure and Strategies for Improving Connectivity in The Greater Toronto and Hamilton Area (GTHA). Report commissioned by the Ministry of Infrastructure (MoI), Government of Ontario.

[21] Rajabiun, R., & Middleton, C. (2018). Strategic choice and broadband divergence in the transition to next generation networks: Evidence from Canada and the US. Telecommunications Policy, 42(1), 37-50.




*International Perspectives on Broadband Divergence:*
*Median download speeds in selected countries*
*Source: M-Lab/Google*

The global experience suggests public sector interventions that discourage incremental and/or duplicative investments in old copper networks and incentivize private sector capital expenditures in new fibre access technologies are associated with improved service quality levels users experience on congestion prone broadband networks.[22] This basic and intuitive insight is relevant for evaluating the two high-level technical models EORN has developed and determining the optimal strategy for the Region. Satellites, wireless, and slow long loop DSL may be the only viable option for people that live and work in rural areas of the today, but this does not have to be the case in the future. While the costs of deploying fixed fibre links to very remote users will remain prohibitive, expanding fibre "middle mile" transport facilities deeper into small hamlets, along rural roads, and emerging residential and business centres can reduce private sector costs facing suppliers and potentially incentivise complementary private sector investments.

[22] Rajabiun, R., & Middleton, C. (2015). Regulation, investment and efficiency in the transition to next generation broadband networks: Evidence from the European Union. Telematics and Informatics, 32(2), 230-244. Rajabiun, R., & Middleton, C. (2017). Regulatory Federalism and Broadband Divergence: Implications of Invoking Europe in the Making of Canadian Telecom Policy. Intereconomics, 52(4), 217-225.
Available at: https://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/vwapj/Attachment2Interecon2017.pdf/$file/Attachment2Interecon2017.pdf

A report from an industry association of rural Internet providers submitted to the U.S. Department of Commerce, National Telecommunications and Information Administration (NTIA) clearly summarizes this issue:[23]

> *"All broadband providers today – wired and wireless alike – realize that the way to increase broadband capability is to increase the amount of fibre in their network. Landline providers are replacing their copper cable with fibre, cable operators are replacing their coax cable with fibre, and even wireless providers are actually replacing their wireless networks with fibre by placing their towers (or small cells) closer to the customer. .... wireless networks rely heavily on the wireline network, and this reliance will only increase with 5G since only a small portion of the last-mile customer connection (i.e., the "local loop") will use wireless technologies. 5G networks are predominantly wireline deep fibre networks, with only a very small portion of their network using a wireless technology. This small wireless portion of the network determines the ultimate broadband capacity of the network, since it is the network bottleneck."*

Based on our previous work on rural broadband projects across Canada, it is also apparent that some smaller Internet service providers similarly recognize the importance of extending "deep fibre" into rural communities as a long-term solution to ensuring they do not fall behind further and can deliver high-quality services consumers demand. The situation is different for large incumbent wireline providers however, which also tend to dominate relatively low cost/high return urban retail markets. Given the relatively low capital intensity of wireless-based services, they have proven to be reluctant to decommission copper in smaller towns, hamlets, and rural areas; instead choosing to upgrade copper/DSL plants and accelerating their wireless deployments in areas where facilities-based competition from cable providers is limited.

More recently, some providers are leveraging Federal subsidies (in the form of accelerated depreciation provisions of the budget) to further accelerate rural wireless deployments to deliver services they claim can meet CRTC's 50/10 Mbps basic speed targets).[24] Given that the dominant fixed network provider in eastern Ontario is already moving towards upgrading its wireless plants vs. upgrading to copper to fibre, the marginal value added from additional subsidies for wireless may be redundant and/or unnecessary.

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[23] Vantage Point (2017), Evaluating 5G Wireless Technology as a Complement or Substitute for Wireline Broadband", February. Page 5. Available at: www.ntca.org/images/stories/Documents/Press_Center/2017_Releases/02.13.17%20fcc%20ex%20parte-ntca%20letter%20submitting%202017%20technical%20paper%20wc%2010-90.pdf

[24] See e.g. https://www.newswire.ca/news-releases/bell-doubling-rural-internet-download-speeds-with-wireless-home-internet-service-expanding-to-rural-atlantic-canada-853970868.html

Given that large providers that dominate the eastern Ontario market have shown little incentives to deploy fibre access networks outside of larger cities and towns, the EORN Gig project (as well as the wired portion of the EORN basic service model), have the potential to “crowd in” complementary private sector investments in high-quality/low latency deep fibre plants unlikely to be built by private sector providers if they are left to their own devices. In this context, the key economic benefit of the EORN Gig model vs. the EORN basic service model proposals is that the larger size of the FTTP footprint that it envisions. Gig model will promote technological change from legacy copper plants deployed decades ago to reliable fibre networks with a long lifespan into the future. In addition to enabling service quality levels that are comparable to urban centres, the Gig model will assist service providers to reduce their operational costs and ultimately decommission copper plants in the medium to long term as fibre take up increases.

From a financial sustainability perspective, rural wireless deployments may be less capital intensive overall, but wireless equipment tends to depreciate and needs to be replaced relatively quickly (every 3 to 7 years) vs. fibre with a lifespan of 20 to 30+ years). In the short term, wireless may appear to be more cost effective than fibre and can help improve headline speeds more quickly. However, in the medium to longer term it can require additional public subsidies for equipment upgrades and tower intensification. From a network management perspective, subsidies for high-capacity fibre access networks can also help improve the quality of wireless services by allowing more high demand users to switch to fibre, thereby reducing the load on capacity constrained/congestion prone wireless plants. In a world of near zero interest rates and accelerated private sector wireless deployments aimed at meeting the CRTC basic service targets, allocating public subsidies to building a fibre rich regional network that complements existing macro cell wireless plants, enables much higher service quality for users, potential deployment of “small cell”/5G networks, and will last a long time, is likely to be more efficient than recurring public subsidies in “macro cell”/fixed wireless platforms.

Nevertheless, it is important to note that in some very remote communities deploying fibre may not be economically justifiable and wireless and/or satellite-based Internet services are likely to remain the only options for people and businesses in these areas. Recognizing this, the Federal government is investing in LEO strategic subsidies for Telesat. It is however not clear if and when LEO technologies will provide residential broadband services in Canada.[25] EORN also recognizes this costing reality in modeling the regional options, targeting up to 95% of dwellings in the Region in both models. We also exclude this 5% of the remote edges of rural eastern Ontario in the estimates of economic benefits that follow later in this report. We note that would be reasonable to suspect that better Internet connectivity in nearby towns and hamlets will also benefit residents and businesses in the very remote edges that are not included in EORN Gig model proposal. At the same time, better connectivity in rural areas and small towns is likely to have positive spillovers into urban centres of larger towns and cities in the Region, which are

[25] Most application so far have been envisioned for high value military and commercial applications.

perceived to have adequate connectivity and not included in the design of the regional broadband improvement model. We also not account for these potential spillovers, baselining our estimates on the 50% of the Region that is considered underserved.

### 2.4. National Policies and Rural Market Failures

There appears to be a growing understanding of the problems poor Internet connectivity creates for Canada's rural regions and remote communities by the federal government, as well as the importance of overcoming this rural-urban digital divide. This recognition was for example a key reason why the Canadian Radio-television and Telecommunications Commission (CRTC) was convinced to reclassify high-speed access as a "basic service" under the Telecommunications Act in 2016.[26]. For the same reason, the CRTC also started a process to repurpose the existing industry funded universal service funding mechanism for telephone access via legacy copper networks to one focusing on promoting broadband development in rural areas and remote communities.[27] In the 2019 Budget, the federal government further committed to a variety of new subsidy mechanisms aimed at promoting supply side incentives for improving connectivity in rural areas and remote communities.[28]

Despite these recent national commitments, it is important to recognize that in addition to cost/revenue driven factors that weaken the business case for investing in rural broadband infrastructure, the federal governments' long-term policy strategy of promoting "facilities-based competition" is itself partly to blame for Canada's growing rural-urban digital divide in broadband quality and affordability. Infrastructure competition may be feasible and desirable in urban centres, but not necessarily in rural areas where there are often limited incentives even for one private sector provider to take on the fixed and operational costs of serving sparsely populated areas. In various wholesale decisions over the past decade (the CRTC 2008-17 and again in the CRTC 2015-326), the regulator has failed to respond to calls from rural communities to impose essential facilities obligations on fibre transport facilities. Unregulated access, when available, can be cost prohibitive.

More recently, due to concern raised by rural communities and smaller service providers, CRTC has initiated a regulatory proceeding to consider barriers posed by access to existing fibre facilities and support structures (e.g. poles, conduits) to the development of high-quality broadband in underserved areas (Telecom Notice of Consultation CRTC 2019-406).[29] The extent to which the CRTC is willing and able to impose wholesale access obligations on transport

[26] Telecom Regulatory Policy CRTC 2016-496.

[27] https://crtc.gc.ca/eng/internet/internet.htm

[28] Budget 2019. Building a Better Canada. Available at: https://www.budget.gc.ca/2019/docs/nrc/infrastructure-infrastructures-internet-en.html

[29] https://crtc.gc.ca/eng/archive/2019/2019-406.htm

capacity and promote infrastructure sharing will be a critical factor in shaping cost structures facing rural communities and service providers contemplating deploying rural fibre and wireless networks. If the CRTC listens to calls from municipalities and rural communities for open access obligations on fibre transport in rural areas, that could reduce the projected costs of both future state models EORN has developed.

In case the CRTC adopts essential facilities obligations on fibre transport (dark fibre or lit services), we suspect the decision will be appealed by large incumbent service providers such as Bell and Telus. However, this speculation is based on previous experience with incumbents' reaction to attempts by CRTC to regulate wholesale access to essential facilities that are expensive to duplicate, particularly in rural areas. Pressures caused by the COVID pandemic may make it more feasible to develop a national regulatory framework that promotes efficient use of existing network assets, limits the scope for inefficient duplication, and fosters cooperation and co-investment in overcoming market failures in rural broadband infrastructure development.

### 2.5. Universal Access: Regional Leadership and National Standards

#### Aspirational Speed Targets vs. Minimum Quality of Service (QoS) Standards

The decision by the CRTC to increase its aspirational speed targets from 5 Mbps download/1Mbps upload it had established in 2011 to 50/10 Mbps in 2016 stipulated that these "are to be the actual speeds delivered, not merely those advertised".[30] On behest of parties representing rural communities (including EOWC/EORN)[31] and consumers with disabilities, the CRTC further recognized that aspirational speed targets by themselves are not sufficient and that it is also necessary to establish minimum universal quality of service (QoS) standards (e.g. latency, jitter, packet loss) and include "unlimited" data in the definition of what is a basic broadband service. In a subsequent 2018 decision, the CRTC established a latency threshold of 50 milliseconds for defining the minimum QoS standard for a "high-quality" service (CRTC 2018-241).[32]

Although commitment to keeping up this standard in the design of the CRTC Broadband Fund or various new federal initiatives appears to be weak, the specification of this latency standard represents some measure of regulatory progress at the national level. Absence of minimum QoS standards or Service Level Agreements (SLAs) has proven to be a critical shortcoming in previous

[30] CRTC 2016-496. Para 81.
[31] See EOWC/EORN intervention to CRTC basic service proceeding at: https://services.crtc.gc.ca/pub/ListeInterventionList/Documents.aspx?ID=223915&en=2015-134&dt=f&lang=e&S=C&PA=t&PT=nc&PST=a
[32] Telecom Decision CRTC 2018-241 – Re CISC Network Working Group – Non-consensus report on quality of service metrics to define high-quality fixed broadband Internet access service

rural broadband subsidy programs around the country in the past, including the more recent Connect to Innovate (CTI) program.[33] Given their long term experience with EORN Phase I project (2009-2014), EOWC/EORN recognize the importance of incorporating minimum service quality guarantees and SLAs in the design of the current initiative, as well as technological challenges in obtaining such guarantees on legacy copper and wireless broadband plants.

A key technological advantage of fibre (as well as next generation/5G wireless) is the capacity to allow for delivery of differentiated services with minimum QoS standard. This capacity represents an important, but hard to quantify, economic benefit from the perspective of both users and providers of multimedia and cloud-based over-the-top (OTT) Internet applications that require reliable low latency connectivity and guaranteed bandwidth (vs. "best effort"/up to xMbps). The impetus to develop the EORN Gig model and extensive support for its implementation by eastern Ontario stakeholders is partly a function of local institutional learning from past experiences with broadband improvement projects in the Region.

As for aspirational "up to x Mbps" capacity targets that are relevant for long term planning and technological choices in the private and public sectors, it is important to note that CRTC 50/10 Mbps target fall short of those adopted by policymakers in a number of other high income countries in terms of both capacity and coverage.[34] Setting higher provincial and local targets and minimum standards will be critical for ensuring that public and private investments are channeled away from incremental improvements in legacy copper and slow wireless broadband plants. Expanding the reach of ultra-high capacity fibre and hybrid fibre/wireless technologies is required for keeping up with long term growth in consumer demand for network intensive Internet applications and services. A key supply side benefit of the EORN Gig model vs. the basic service 50/10 model is that its higher aspirational targets in the Gig model are more motivational for both the public and private sector stakeholders to work towards. This should help promote co-investment incentives, which will ultimately benefit all groups by reducing the costs of delivering high quality connectivity to people that live and work in rural eastern Ontario.

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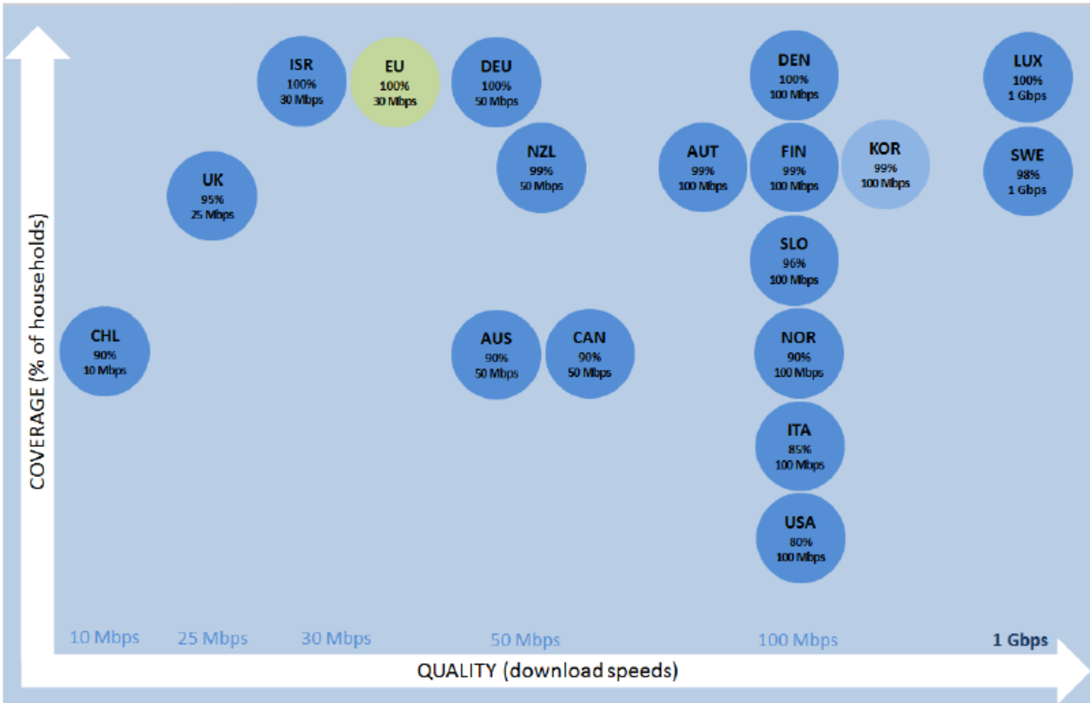
[33] See e.g. Rajabiun, R., & Middleton, C. (2013). Rural broadband development in Canada's provinces: An overview of policy approaches. Journal of Rural and Community Development, 8(2). Available at: https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/DGTP-002-2015-RajabiunMiddleton-Attachment4.pdf/$FILE/DGTP-002-2015-RajabiunMiddleton-Attachment4.pdf
Independent Auditor's Report. Office of the Auditor General of Canada. 2018 Fall Reports. Connectivity in Rural and Remote Communities. Available at: http://www.oag-bvg.gc.ca/internet/English/parl_oag_201811_01_e_43199.html#hd4a

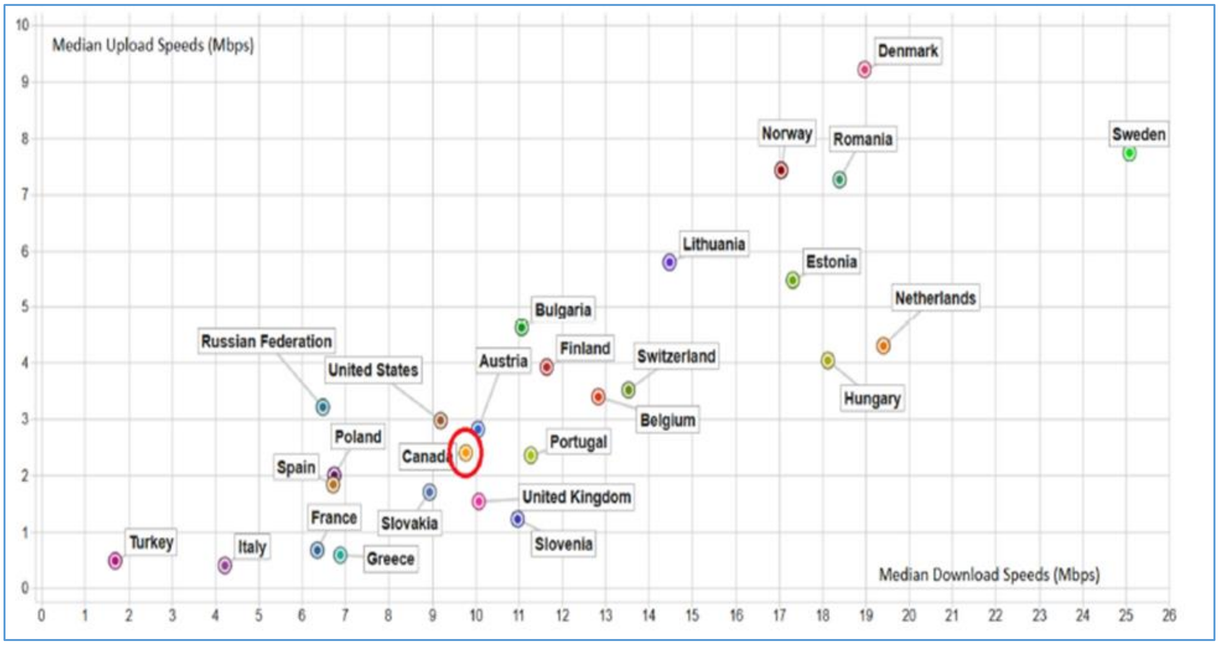
[34] OECD (2018) Bridging the Rural Digital Divide. OECD Digital Economy Paper. No. 265. Available at: https://www.oecd-ilibrary.org/science-and-technology/bridging-the-rural-digital-divide_852bd3b9-en




*Matrix of OECD national broadband targets in coverage and capacity*
*Source: OECD*

### 2.6. Broadband Infrastructure Quality in Canada and Eastern Ontario

More than 80% of Canadians live and work in a small number of urban centres, usually with access to two broadband infrastructure providers offering retail services (in addition to some smaller providers that rely on the physical infrastructure of the duopoly of incumbent cable and telecom companies to offer retail subscriptions). Canada has one of the highest cable broadband penetration rates, which can offer faster speeds than legacy copper last mile networks of incumbent telecom providers. Despite this, measured broadband speeds in Canada tend to be about average compared to other advanced countries and substantially lower than countries that are further along the long-term path in the transition to FTTP technologies.

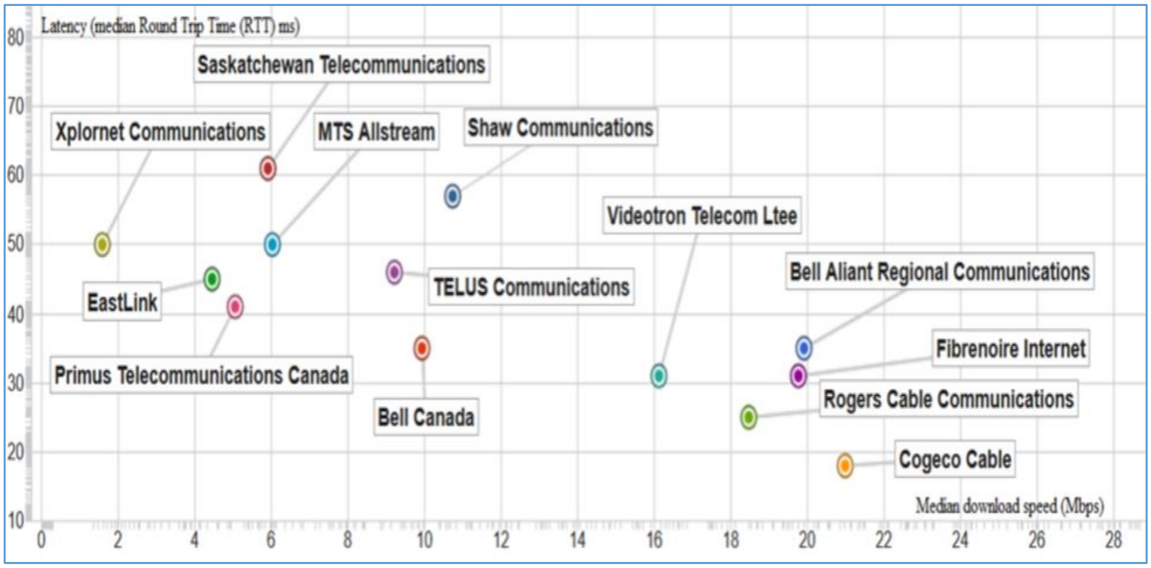



*Measured Download and Upload Broadband Speeds medians*
*Source: M-Lab/Google; 2016*

There is significant variation within Canada in the quality of Internet access services providers deliver as well. These differences partly depend on the providers' technological endowments. Cable and fibre-based providers (e.g. Rogers, Shaw, Cogeco, Bell Aliant) tend to deliver higher speeds and lower latency (a key measure of quality of service/connection delays users experience; the lower the better) than large copper-based/DSL providers (e.g. Bell, Telus), which had been accelerating their FTTP investments in urban cores and larger towns (at least prior to the COVID outbreak). Effective bandwidth users experience also depends on providers' strategic technological choices and capacity investments.

Bell Aliant decision to accelerate FTTP deployments in Atlantic Canada nearly a decade ago was a deliberate one and remains relevant for understanding the importance of strategic choices of operators about technology. It is also a notable decision because it stands in sharp contrast to the strategy adopted by Aliant's parent/sister company Bell Canada at the time (or Telus), which instead chose to adopt a fibre-to-the-node (FTTN) only + copper/DSL last mile strategy in their regional markets. Cable providers like Shaw in the west and Eastlink initially lagged behind their counterparts Rogers, Videotron, and Cogeco, despite similar technological endowments.[35]

[35] Rajabiun, R., & Middleton, C. (2018). Strategic choice and broadband divergence in the transition to next generation networks: Evidence from Canada and the US. Telecommunications Policy, 42(1), 37-50.




*Broadband Service Quality Variation in Canadian Internet Service Providers medians*
*Source: M-Lab/Google; 2016*

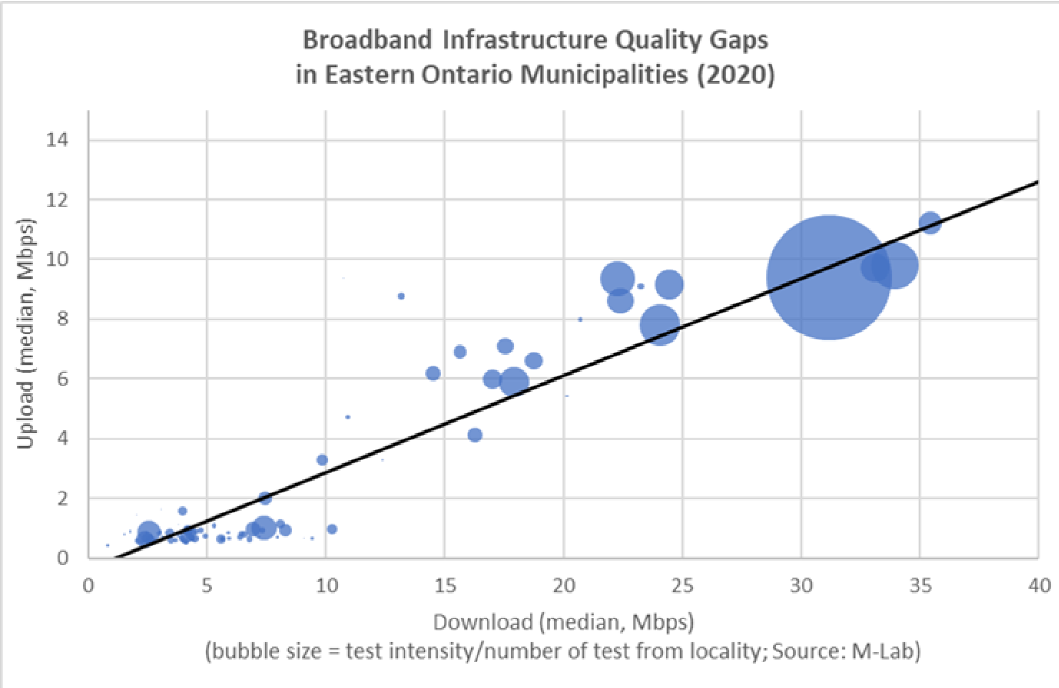
EORN has previously mapped gaps in service speeds on offer in the Region using data provided by service providers to CRTC and Innovation, Science and Economic Development Canada (ISED. According to EOWC/EORN's estimates based on data on maximum advertised speed on offer as compiled by ISED, approximately 50% (285,000 of dwellings/pseudo-households)[36] in eastern Ontario currently cannot access services that meet the 50/10 Mbps CRTC established back in 2016.[37] This translates to nearly half of eastern Ontario's population outside of Ottawa (approximately 600,000).

In terms of effective bandwidth that is available/quality of service people experience, the subsequent figure provides an overview of current state of connectivity in eastern Ontario municipalities/localities. User generated Internet speed measurements from eastern Ontario in the months before and after the COVID lock-downs document that effective median downstream bandwidth users experience in many small towns, hamlets, and rural areas of the Region remains below 10 Mbps (below 5 Mbps in some areas; and below 1 Mbps in terms of upload speeds; i.e. the cluster of bubbles on the lower left hand side of the figure).

This level of service may have been adequate for basic Internet applications that were essential before the pandemic (e.g. email, web browsing, downloading media content). However, they are not sufficient for enabling reliable use of multimedia and cloud-based applications requiring reliable, more symmetric speeds, and low-latency connectivity. It is precisely these applications

[36] https://open.canada.ca/data/en/dataset/b3a1d603-19ca-466c-ae95-b5185e56addf
[37] Telecom Regulatory Policy CRTC 2016-496. https://crtc.gc.ca/eng/archive/2016/2016-496.htm

that have now become vital to the ability of people to work from home, continue with their education, receive healthcare, and communicate with their friends and loved ones.




## 2.7. Proposed Regional Strategies

Since its inception more than a decade ago, the primary objective for the development of EORN for regional stakeholders has been to promote economic development by expanding access to higher speed broadband in rural eastern Ontario. EORN Phase 1 project helped accelerate upgrades to DSL and expand fixed wireless coverage in the Region to standards of service higher than the 5/1 Mbps aspirational targets CRTC had adopted back in 2011. EORN Phase 1 project was completed in 2014. Today, both wired and wireless service providers advertise speeds of "up to" 25 Mbps download in available in most rural areas of the Region (and increasingly "up to" 50 Mbps). The challenge that COVID has highlighted is that the actual speeds and service quality levels people are able achieve is no longer good enough for using the network intensive multimedia and cloud computing applications that are now essential in a reliable manner (potentially by multiple people on multiple devices simultaneously within the same household/dwelling).

In response to demand for better connectivity by residents, businesses, and public sector stakeholders in the Region, EOWC/EORN have developed and costed two high-level technical network development models. Future state scenarios EOWC/EORN have outlined range from a lower cost option designed to improve regional network capacity to deliver speeds that satisfy "basic service" aspirational speed targets of 50/10 Mbps (with a combination of wireless and wired/fibre access technologies), as well as more ambitious proposals that would expand access to ultra-high capacity/low latency fibre-to-the-premises (FTTP) networks to 95% of premises in underserved areas of the Region (266,000 dwellings/premises).

The basic service model requires around $700 million in fixed capital expenditures to expand access to 50/10 Mbps service offers, while the Gig model is estimated to require around $1.6 billion in capital expenditures. EOWC/EORN estimate that a public subsidy between 60 to 80 percent of the total fixed capital expenditures will be required to bring up the expected rate of return facing private providers sufficiently to attract complementary private investments (i.e. the remaining 40% and 20% of capital requirements of the two models respectively). The key difference between the two models is that with the basic service model, access to wireline fibre networks will be expanded to only around 100,000 households/premises vs. 250,000 in the Gig model. In the basic service model, connectivity for the remaining 150,000 households/premises will be improved by expanding fibre middle mile, building new towers, and upgrading fixed wireless network capacity.

**Efficiency and equity objectives:** In broad terms, the Gig model would be more efficient from the perspective of people that live and work in areas that will have to rely on less reliable and capacity constrained large cell wire less technologies. It is also more equitable than the basic service model as it would expand access to fibre-based services that are now available in Canada's urban cores, as well as in larger cities in eastern Ontario. However, relative to the basic service model, the Gig model would require $600 to $800 million more in public subsidies to implement. A key question for regional and upper-tier stakeholders at this stage of planning and exploration of funding options is if the economic benefits of the additional investment the Gig model in terms of efficiency and equity gains are worth the additional subsidies it requires compared to the cheaper wireless option for higher cost areas the plan aims to serve (both plans designed to achieve 95% coverage; the remaining 5% in very high cost/sparsely populated areas are excluded from the regional models).

**From technology models to economic development:** Having modeled technical options and estimated required expenditures, EOWC/EORN need to better understand potential differences in expected economic benefits associated with each approach to network development. Understanding the differences between expected benefits from incremental improvements vs. building scalable "deep fibre" networks with scalable multi-gig capacity is important for local and upper-tier policymakers that recognize the need for better broadband from residents and businesses, but also face binding budget constraints and have other important funding priorities. Given persistent private sector under-investment and market failure in deploying high-quality broadband in small towns, villages, and rural areas, broadband infrastructure improvement support may have an important role to play in achieving other policy priorities (e.g. economic recovery, productivity, employment growth, education, healthcare, etc.). The next section explores some of the key channels through which the EORN Gig project can generate positive economic spillover effects within the Region and beyond.

## 3. Economic Benefit Estimates

Market failures can occur and persist in network industries because, for some reason, the market mechanism cannot capture potential value that can be achieved through cooperation (i.e. inefficient Nash Equilibrium in the language of game theory). Coordination failures in decentralized systems can be persistent particularly in the case of adoption of new standards and technologies.[38] This section provide examples of specific channels through which the EORN Gig model can generate additional value that market processes have difficulties capturing and will likely be foregone without public sector leadership, coordination, and financing commitments to deploying ultra-high speed/low latency fibre access networks in eastern Ontario.

For the most part, the analysis and estimates are limited to those that might accrue within underserved areas EORN has identified and plans to target with the broadband improvement projects. Consequently, we do not account for positive regional spillovers in larger towns and areas that already meet the 50/10 Mbps basic service standards that are likely if nearby rural areas, hamlets, and smaller towns around them have better broadband and prospering. Furthermore, we focus primarily on the benefits of the Gig model as it is the preferred regional option at this point and will have a more pronounced economic impact than the basic service model.

To highlight some of market failures and estimates of benefits/opportunity costs of investing/not investing in high-quality broadband, we compiled and analyzed three distinct sets of data:

**a) EORN baseline model data**: Data capturing the overall size/number of those premises/residents in underserved areas the projects aim to target, planned capacity and technologies under consideration, and distribution of required network assets in different elements of the network under the two scenarios (i.e. fibre middle, last mile deployments, short vs. long lives assets, etc.).

**b) Regional economic data:** Data capturing the size and characteristics of the regional and national economy, property values, tax rates, and other variables relevant for capturing the status quo. Data sources include Statistics Canada, Ontario Government publications, and Eastern Ontario Leadership Council. COVID impacts on employment and GDP. This analysis focuses primarily on region wide impacts and does not dig further into local variations within rural eastern Ontario due to both data and time limitations.

**c) Ultra-fast/FTTP broadband impact elasticities:** In order to obtain reasonable estimates of potential economic benefits of high-quality broadband in rural eastern Ontario, we have conducted an extensive literature review of empirical research that aim to quantify the linkages between

[38] Jackson, M. O., & Yariv, L. (2007). Diffusion of behavior and equilibrium properties in network games. American Economic Review, 97(2), 92-98. https://www.aeaweb.org/articles?id=10.1257/aer.97.2.92

network infrastructure development and indicators of economic outcomes. While there is a large body of international and Canadian research on the impacts of growth in 1st generation broadband access in the 2000s and early in the past decade, we found only a handful of studies on the economic impacts of ultra-fast/FTTP in Canada and internationally.

Based on the literature review of particular angles on the topic (e.g. consumer surplus, impact on GDP, employment, property values, healthcare costs, etc.), we develop a range of reasonable marginal impact elasticities, which we then use to estimate potential economic benefits along different channels to the case of eastern Ontario Gig model. To cross-check the robustness of our high-level estimates, in addition to using broadband specific impact estimates we utilize generic infrastructure investment multiplier estimates for Ontario and Canada. We generally rely on mid-range estimates in drawing inferences, but address some of the potential sources of under/over estimation bias in the discussion.

### 3.1. Demand Side Benefits: Consumer Welfare Gains from High-quality Broadband

From an economic perspective, the primary beneficiaries of technological change tend to be consumers that value higher quality and lower prices diffusion of innovative technologies enables. In the case of broadband connectivity in eastern Ontario, existing speeds on legacy copper and wireless networks may be good enough for some proportion of users. For others, the 50/10 basic service capacity targets might be sufficient. However, there is some proportion of residents and businesses for whom such service levels are inadequate today, including families with multiple users that have to be connected simultaneously to network intensive applications that require low latency.

We do no have data that allows for estimating these proportions in detail for eastern Ontario. Estimates based on demand side modeling from Europe before COVID suggest that by 2025, around 40% of households will require connections with at least 300 Mbps symmetric capacity.[39] With COVID telecommuting and school from home, proportion of households with demand for ultra-high capacity/low latency connectivity is likely to be much higher than this estimate. Current speeds and future plans under the EORN basic service model are not necessarily sufficient to satisfy demand from the substantial proportion of subscribers with demand for Gig level services today, or tomorrow in all likelihood. The opportunity costs in terms of consumer surplus that is forgone from a lack of access to reliable high-quality fibre-based connection is likely to be substantial.

[39] WiK Consult/Ofcom (2018). The Benefits of Ultrafast Broadband Deployment. https://www.ofcom.org.uk/__data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf

To quantify this consumer welfare loss/potential gain, we rely on estimates from previous research using proprietary data from large North American broadband infrastructure providers, which suggests that that potential consumer surplus from FTTP to be somewhere in the range of $200 to $300 per month per subscriber (at zero price).[40] These benefits arise from the time savings and productivity gains that high-availability, high-quality and more symmetric fibre wireline connectivity enables. At market prices of about $120 for Gig services today in Ontario (where available), additional per subscriber consumer surplus from FTTP (over legacy cable and DSL) by a subscriber can then be estimated to be between $80 to $200 per month (depending on subjective evaluation of the value of high-quality vs. basic Internet). This range applies to additional gains over cable and DSL-based services, and therefore likely to be even bigger for people that have little option but to rely on wireless. Our estimates below are therefore relatively conservative.

Using these baselines, the subsequent table estimates potential gains in consumer welfare for people in rural areas of eastern Ontario if Gig level services are introduced. Our mid-range estimates suggest that at current market prices for Gig service (in urban areas "where available"), deploying Gig services in underserved areas of eastern Ontario would generate an average annual per subscriber benefit of approximately $1,000 over existing legacy wireline and wireless-based services. At a take-up rate of 50%, this translates to around $130 million annually in additional consumer surplus accruing to residents and businesses with demand for high-quality connectivity in rural eastern Ontario. In the 10 years after FTTP deployment, consumer welfare gains from improved service quality will exceed the $1.2 billion of public investments EORN estimates are required for the Gig project.

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[40] Original estimates in USD, converted to CAD at 20% discount. See: Nevo, A., Turner, J. L., & Williams, J. W. (2016). Usage-Based Pricing and Demand for Residential Broadband. Econometrica, 84(2), 411-443. Available at: https://www.nber.org/papers/w21321.pdf

| Consumer welfare/surplus gains from quality of service effects of FTTP deployments in rural eastern Ontario | | | |
|---|---|---|---|
| **Qualify of service impacts from FTTP in eastern Ontario** | | | |
| **Assumptions** | **Mid-range** | **Low** | **High** |
| Consumer surplus on ultra-high capacity/Gig/FTTP (at price zero, per month, $) | 243 | 198 | 288 |
| Consumer surplus on 1st gen./legacy broadband (at zero price, monthly, $) | 122 | 99 | 144 |
| Current price for Gig (where available) | 120 | 110 | 130 |
| Current price for 1st legacy DSL, wireless, satellite | 80 | 50 | 130 |
| FTTP subscribers in target area (thousands) | 133 | 106 | 186 |
| **Estimates** | | | |
| Consumer surplus on 1st gen. at current market prices (monthly) | 42 | 49 | 14 |
| Consumer surplus on Gig/FTTP at current Gig/FTTP prices in urban area(monthly | 123 | 88 | 158 |
| Per subscriber gains in transition from 1st to NGN (monthly) | 82 | 39 | 144 |
| Annualized welfare gains per subscriber ($) | **978** | 468 | 1728 |
| Consumer welfare gains in eastern Ontario (annual, $, millions) | **130** | 50 | 322 |

Despite the potential for large gains in consumer value from FTTP deployment, it is important to point out that market failures in deploying FTTP are common, even in urban areas. One reason for this is that the average additional willingness to pay for Gig services over basic service packages tend to be much lower than the subjective evaluations of benefits by high demand users. Although a substantial, and likely growing, proportion of high demand users may be willing to pay more than the market price of $120 for FTTP-based services, others in their neighbourhood, hamlet, and area of town may not be willing or able to do so. One reason for this is that low use/value users perceive existing fibre-to-the-node (FTTN) + DSL/cable to be good enough. Previous research focusing on FTTP deployment incentives in the Greater Toronto and Hamilton Region (GTHA) suggests that expected take up rates below 50% tend to limit the incentives of copper plant providers to deploy FTTP in mid-sized municipalities in order to compete with high-speed cable providers in terms of service quality.[41] In rural areas and small communities where cable

[41] [41] Rajabiun R. (2016). State of Broadband Internet Infrastructure and Strategies for Improving Connectivity in The Greater Toronto and Hamilton Area (GTHA). Report commissioned by the Ministry of Infrastructure (MoI), Government of Ontario.

companies have little incentives to enter, expected take up rates for FTTP may be higher given the larger gap in service quality between fibre and other available options (FTTN+ DSL, wireless, satellite).

In addition to quality improvements, one objective of the EORN Gig model is to promote service affordability in exchange for public investments in a public-private partnership. The estimated Average Revenue Per User (ARPU) EORN has used in modeling its plans is $80 per subscriber per month for fibre-based access, which is $40 per month below the current market prices for Gig services in Ontario’s urban cores where available. Ignoring the quality of service improvement effect on consumer welfare, a strategy of promoting Gig services at a competitive price has the economic benefit of increasing expected take up rates for FTTP and consumer surplus gains compared to the model above. Our mid-range estimates of just the price commitment effects put additional consumer welfare gains at about $500 per year per subscriber, or $65 million annually in the target area (at 50% penetration).

**Consumer welfare gains from price effects of EORN Gig project**

| **Assumptions** | Mid-range | Low | High |
|---|---|---|---|
| Current monthly prices for Gig service (where available) | 120 | 110 | 130 |
| EORN Gig model target average price | 80 | | |
| % FTTP take up (out of 266,000 premises) | 50 | 40 | 60 |
| **Estimates** | | | |
| Per subscriber annual savings relative to comparable service at current market prices | **480** | 360 | 600 |
| FTTP Subscribers (thousands) | 133 | 106 | 186 |
| Total consumer savings in eastern Ontario (annual, millions) | **64** | 38 | 112 |

To sum up consumer welfare impacts of proposed projects, the following table provides an overview of the results across the range of estimates. Given that the EORN 50/10 model includes expanding wired fibre services to 100,000 premises in the Region, its impacts may be captured by the low diffusion state estimates, while a successful FTTP project in terms of penetration and take up by residents can be interpreted as the high diffusion future state resulting from the EORN Gig model. Over an extended period after deployment, consumer value gains that can be generated from either model will exceed required public subsidies for both EORN models (i.e. $500 million for the basic service and $1,2 billion for the Gig model). The size of the consumer value gains will however be 2 to 4 times larger in the optimistic case of the Gig model with high penetration and high usage of FTTP vs. the more incremental basic service approach (i.e. low diffusion state). Given increased demand for reliable connectivity driven by COVID lockdowns, we expect the high-diffusion state to be more realistic.

| Summary of Consumer Welfare Impacts | | | |
|---|---|---|---|
| **Additional Consumer Surplus in future FTTP diffusion/take up states (annual)** | Low | Mid | High |
| Without discount from current Gig prices in urban centres | 50 | **130** | 322 |
| Over 10 years (millions) | **500** | **1300** | **3220** |
| In case pricing commitment of $80 per month | 88 | **194** | 434 |
| Over 10 years (millions) | **883** | **1,938** | **4,337** |

## 3.2. Supply Side Benefits: Capital vs. Operational Cost Minimization

While the estimated fixed capital expenditures for EORN 50/10 model is about one third of the EORN Gig model, FTTP networks tend to be substantially cheaper to operate and scale as demand growth compared to legacy copper, cable, and wireless. In addition to consumer value that deploying fibre access networks can generate in rural eastern Ontario, the EORN Gig model has the potential to significantly reduce operational costs facing service providers. According to estimates from RBC based on proprietary data from Bell on Bell Aliant Fibre deployments in Atlantic Canada between 2010-2014, moving subscribers from copper/DSL to FTTP reduced per subscriber operational costs by around $100 per subscriber per year.[42]

FTTP operational savings are primarily driven by reduced maintenance costs (e.g. truck rolls) and the need for customer support compared to legacy plants. Once fibre is deployed, provisioning and maintenance can be accomplished centrally to a large degree. Furthermore, old and expensive to maintain copper plants can be entirely decommissioned. The subsequent table provides estimates of potential operational cost avoidance in rural eastern Ontario. These estimates only consider per subscriber operational cost reduction per Bell Aliant historical estimates, and not the costs of decommissioning old copper plants, additional value from recycling copper, or operational cost savings from increased energy efficiency from fibre optics compared to DSL, cable, or wireless, etc. Our mid rage estimates suggest that accelerating the transition from copper to fibre with the EORN Gig model can reduce operational costs of service providers between $13 to $26 million annually, totally up to $200 million in 10 years with full copper decommissioning.

[42] RBC Capital Markets, Telecom Scenario Report. August 2015.

| Operational cost avoidance from FTTP deployments in rural eastern Ontario | | | |
|---|---|---|---|
| **Assumptions** | Mid-range | Low | High |
| Copper to fibre operational cost reduction per subscriber per year | 100 | | |
| % FTTP take up (out of 266,000 premises) | 50 | 40 | 60 |
| FTTP Subscribers (thousands) | 133 | 106 | 186 |
| **Estimates** | | | |
| Annual operating cost reduction (thousands) | 13,300 | 10,640 | 18,620 |
| With full copper decommissioning | 26,600 | 26,600 | 26,600 |
| Over 10 years FTTP ramp up and copper decommissioning; average | **199,500** | **186,200** | **226,100** |

A second important source of benefit from the EORN Gig model for providers compared to wireless options in play today, or those proposed in the ERON basic service model, is reduced need to reinvest in equipment. While significantly less capital intensive to deploy today, wireless equipment depreciates relatively quickly and has to be replaced every 3 to 7 years. For the purposes of this analysis we assume 5 years. Costs of wireless equipment with a short lifespan makes up about a quarter of CAPEX in the EORN 50/10 model (~$200 out of $600 million). In sharp contrast, fibre optic middle mile and access networks with a long lifespan (20 to 30 + years) represent around $1.5 billion out of the $1.6 billion initial capital cost of the EORN Gig model. As documented in the subsequent table, the costs of replacing wireless equipment in the EORN 50/10 model start to add up over multiple refresh cycles, potentially reaching up to $800 million over the long lifespan of fibre assets in the Gig model.

This economic benefit almost totally balances the difference between the capital cost estimates of the two models in current dollars as it makes the total costs of both models broadly equivalent over a long time horizon. Over the medium term, EORN's 50/10 model is likely to require further private investment and/or subsidies to upgrade relatively expensive wireless equipment that will serve 150,000 of premises in the Region under this incremental plan (i.e. the per household cost of replacing equipment on wireless over 4 refresh cycles will be about $3700 higher than on fibre at current market prices). Over the first 10 years/2 equipment refresh cycles, we expect the EORN 50/10 model will require around $275 million more in additional investment over the Gig model in order to ensure outdated wireless equipment and growing oversubscription ratios does not start to degrade service quality people experience in underserved areas of the Region.

| Future costs of equipment refresh in EORN basic vs. Gig models | |
|---|---|
| **Assumptions** | |
| **Short lived assets: Last mile network equipment cots per HH; not including CPE** | |
| Wireless (to upgrade to 50/10); needs to be replaced every 3-7 years | 1000 |
| FTTP (for 50/10); can be upgraded to Gig at low cost | 60 |
| FTTP (for Gig) | 75 |
| **Estimates (over 20 years/4 refresh cycles)** | |
| Wireless equipment replacement cost per HH | 4000 |
| FTTP equipment upgrade cost per HH | 300 |
| EORN basic service/50/10 model | |
| If 150,000 HH on wireless last mile | 600,000,000 |
| For 100,000 HH on fibre last mile | 30,000,000 |
| Total reinvestment required | 630,000,000 |
| EORN Gig model | |
| If 266,000 HH on fibre last mile (Gig) | 79,800,000 |
| Difference between ERON 50/10 vs Gig designs over a 20 year life cycle | |
| **Per household** | **3700** |
| **Provider OPEX reduction from Gig vs. basic models** | **550,200,000** |
| **Over 10 years (2 refresh cycles)** | **275,100,000** |
| **Over 30 years (fibre lifespan; 6 refresh cycles)** | **825,300,000** |

Given the substantially lower operational, equipment refresh, and capacity scaling costs in the EORN Gig model, it has the potential to become financially sustainable once initial capital expenditures are deployed. As in many other wireless broadband projects around the country, including EORN Phase 1 project, operational expenditures required to sustain headline connectivity speeds on publicly subsidized rural broadband solutions have proven to be one of their key shortcomings as demand grows over time. The result is increasing oversubscription ratios and quality of service degradation for people that have little option by to rely on wireless (or even slower/more expensive satellites). From a policy development perspective, heavy emphasis on wireless in past rural broadband programs can be viewed as one of the key reasons for renewed calls on policymakers to do something with sub-par broadband every few years as capacity constraints drive the need for suppliers to impose data caps/throttle capacity on congestion prone wireless networks.[43]

Finally, it is important to note that the EORN Gig model incorporates substantially more middle mile fibre and local Points of Presence (PoP) that enable high capacity traffic aggregation from communities across rural eastern Ontario compared to the basic service design. Consequently, the Gig model has the potential to benefit both service providers by reducing deployment costs of

[43] See e.g. https://www.cbc.ca/news/canada/nova-scotia/eastlink-chided-by-premier-stephen-mcneil-over-rural-internet-cap-1.3144565

network technologies that meet the needs of their customers (assuming open access obligations are in place). This would be particularly important for deployment of new hybrid fibre/"small cell" networks in small towns and hamlets around the Region. The macro cell/fixed wireless portion of the basic service model reduces initial capital expenditure and subsidy requirements. It may also present a useful short term solution to increasing headline broadband speeds in rural eastern Ontario. However, the wireless portion of EORN's basic service model will not provide the "deep fibre" coverage required to reduce the costs of ultra-high capacity fibre and 5G access network deployments in the future that will limit the incentives of service providers to deploy such broadband technologies in rural communities.[44]

## 3.3. Spillover Examples: Market Failures and Value Capture

Basic supply and demand side costs and benefits outlined above provide some perspective on the scope of gains from technological change involved in the transition from copper to fibre optics as proposed under the EORN Gig model. Given the fundamental nature of multipurpose broadband networks to life and work, it can be difficult to appreciate why market forces fail to capture the potential value of better broadband and why public sector leadership and investment is required. To illustrate some of more concrete channels through which economic value is foregone with sub-par broadband and can be generated with better broadband, this section focuses on a number of specific examples that help capture some of hard to measure quality of life, productivity, and prosperity gains that may arise from accelerating fibre deployments in underserved areas of eastern Ontario.

### *3.3.1. Property values and municipal taxes*

By improving quality of life and the range of opportunities available for social and economic participation, expanding access to ultra-high speed/FTTP networks has the potential to increase property values. Research on the impact of broadband infrastructure quality variation and property values from the U.S. suggests that high-capacity fibre connections have a marginal positive impact of about 3% on median home values, with some variation around this due to regional, competitive, and other sources of variation in home values (ranging from 1% to 7%).[45]

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[44] [44] Rajabiun, R. and Hambly, H (2018). Rural Fibre and 5th Generation Wireless: Substitutes or Complements? Regional and Rural Broadband (R2B2), University of Guelph. Available at: http://www.r2b2project.ca/publications/policy-briefs/

[45] Molnar, G., Savage, S. J., & Sicker, D. C. (2015). Reevaluating the Broadband Bonus: Evidence from Neighborhood Access to Fiber and United States Housing Prices. FTTH Council Americas. http://scandiainternet.com/documents/FTTH%20Study.pdf
https://www.bbcmag.com/pub/doc/BBC_Jul15_GigabitHighway.pdf
Molnar, G., Savage, S. J., & Sicker, D. C. (2019). High-speed Internet access and housing values. *Applied Economics*, 51(55), 5923-5936. https://www.tandfonline.com/doi/abs/10.1080/00036846.2019.1631443
Deller, S., & Whitacre, B. (2019). Broadband's relationship to rural housing values. *Papers in Regional Science*, 98(5), 2135-2156. https://cced.ces.uwex.edu/files/2019/07/Deller-Whitacre-2019.pdf

Unfortunately, the literature review for this report was not able to identify previous research analyzing the property values in rural regions of Canada.

To estimate the impact of deploying fibre access networks on property values in eastern Ontario, we make use of the baseline estimate from U.S. studies. While there can be significant differences in regional property markets within the U.S. and Canada, there are also key similarities in the structure of the telecom sector and rural market failures. For example, both Canada and the U.S. have relatively unique broadband market structures with relatively high penetration of faster cable networks in urban centres and larger towns. Cable enables access to higher speed services in the absence of fibre and some incentives for facilities-based competition for incumbent copper network operators to invest in FTTP in order to compete for service quality/speed in urban cores. However, due to limited facilities-based competition from cable companies, incentives of incumbent copper/DSL providers to improve network quality and expand FTTP into smaller towns and rural areas has remained limited in both countries and most regions within them.[46] The case of rural eastern Ontario is similar to this broader pattern in broadband infrastructure development and rural market failures in North America.

Underserved rural areas in eastern Ontario are situated within a ring of larger cities where facilities-based competition has helped increase FTTP penetration over the past few years. Incentives of incumbent copper network operators to expand fibre access networks beyond the existing cable footprint remains limited (i.e. no business case to decommission copper/deploy fibre). At the same time, cable companies appear reluctant to expand into higher cost/low revenue areas beyond the reach of their existing plants.

The proximity of rural eastern Ontario to urban centres with relatively expensive properties represents both a threat and opportunity. With COVID, properties that lack access to high-quality broadband are going to be particularly hard to sell or would require a heavy discount. On the other hand, given large gaps between prices in urban areas with adequate broadband and rural eastern Ontario, deploying high-quality fibre access networks in the Region has the potential to attract people searching for more affordable living, larger spaces, and rural life. The impact of fibre on property values in eastern Ontario may therefore be on the higher end of the range of estimates from the U.S. market from before COVID. On the other hand, very sparsely populated northern parts of eastern Ontario are unlikely to attract newcomers. In these areas, the benefits of improving connectivity in terms of property values would be positive, but likely on lower that areas that are closer to larger towns and cities.

[46] Rajabiun, R., & Middleton, C. (2018). Strategic choice and broadband divergence in the transition to next generation networks: Evidence from Canada and the US. *Telecommunications Policy*, 42, 37-50. https://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/vwapj/Attachment1JTPO2018.pdf/$file/Attachment1JTPO2018.pdf

As documented in the table below, we estimate if implemented, the EORN Gig project has the potential to increase the median value of a typical home in rural eastern Ontario by approximately 3%, or $7500 per home. Once incorporated into property tax assessments, estimated home value gains from deploying FTTP in underserved areas of eastern Ontario can increase the property tax revenue generation capacity of municipal governments by approximately $20 million per year.

| **Impact of fibre access network deployments on property values and municipal taxes in rural eastern Ontario** | | | |
|---|---|---|---|
| **Assumptions** | **Mid-range** | **Low** | **High** |
| Number of properties to be served with FTTP (count) | 250,000 | | |
| Median value of home in Eastern Ontario ($) | 250,000 | | |
| Broadband premium | 3% | 1% | 7% |
| Municipal property tax rate (% of value) | 1% | 0.75% | 1.25% |
| **Estimates** | | | |
| Median value with FTTP | 257500 | 252500 | 267500 |
| Added property value per home ($) | **7500** | **2500** | **17500** |
| Additional **municipal** revenue per home per year | 75 | 25 | 175 |
| Annual municipal revenue increase ($ **million**) | **19** | **6** | **44** |
| Additional property taxes over 10 years | 188 | 63 | 438 |

**Market failures as coordination failures:** EORN Gig project proposes to expand ultra-high capacity fibre access networks to around 250,000 properties in rural eastern Ontario. As documented in the table above, we estimate private benefit of fibre connections in terms of median property values in rural eastern Ontario is marginally higher than EORN's estimated per household costs of deploying fibre in underserved areas of the Region (~$7,000 benefit vs. $4000-$6000 cost per home). Positive spillovers in property values from high-quality connectivity tend to be hard to capture via "market forces" as individual owners have different private valuations of the benefits of better connectivity on the value of their asset and cannot commit to sharing the fixed costs of deployments into their communities with each other (i.e. persistent sub-optimal/inefficient Nash Equilibrium).[47]

**Insufficiency of municipal taxes/borrowing:** Even in the very long run and under extremely optimistic assumptions about home value gains and property tax hikes, the potential tax revenue gains for municipal governments from better broadband will fall significantly short of public subsidies EORN estimates will be required to overcome persistent market failures in the provision of high-quality broadband in rural parts of the Region (i.e. just over $400 million over 20 years in

[47] Jackson, M. O., & Yariv, L. (2007). Diffusion of behavior and equilibrium properties in network games. American Economic Review, 97(2), 92-98. https://www.aeaweb.org/articles?id=10.1257/aer.97.2.92

additional property tax revenue under optimistic assumptions vs. $1.2 billion CAPEX subsidy today on the EORN Gig project proposal). Due to their limited taxation capacity, small rural municipalities cannot therefore be expected to tax and/or borrow to make investments that are required to capture the value of reliable connectivity on property values and tax revenues.

**Local/in-region heterogeneity:** The impact of deploying wireline fibre access networks in terms of home values is likely to be larger in rural areas near large population clusters where there is already access to higher speed cable/fibre wireline services and housing prices are relatively less affordable. The value gain in relatively remote and sparsely populated is likely to be relatively lower due to limited demand for those properties from outsiders/new residents. Property value gains can nevertheless arise as people with better broadband are likely to have stronger incentives to invest more capital in their properties to increase the subjective values of their homes from their own perspective (e.g. potentially with the objective of living independently in them into their old age). Property market prices or tax assessment values do not necessarily capture these sources of positive spillovers on the value of homes in areas with declining and older populations.

**COVID projections:** COVID pandemic creates both opportunities and threats to the value of homes in rural areas. Homes where potential buyers cannot access the Internet reliably are likely to command a growing discount, while those with ultra-high capacity fibre access can command a relatively higher premium. This has equity implications given that primary residences represent the primary vehicle for capital asset formation. The 3% premium/discount for homes with reliable/sub-par broadband may therefore represent a substantive underestimation of the gaps in property values within the Region associated with basic vs. Gig broadband availability.

### *3.3.2. Telecommuting and emissions reductions*

One of the key benefits of better broadband in rural areas is to enable telecommuting for workers (in industries where teleworking is feasible). Telecommuting possibilities open a large set of potential opportunities for employment and commerce. Beside expanding such opportunities to residents and businesses in rural areas, teleworking enables substantial private cost avoidance for those who can work from home in terms of transportation and related costs, which in turn has a public benefit of reducing greenhouse gas emissions from households. With COVID, some employers are recognizing that teleworking is more feasible than they perceived previously, vacating expensive offices, and cutting operational costs. This can encourage a pronounced increase in telecommuting in the medium to longer term, with potentially greater private and public economic benefits.

To quantify these potential benefits, we rely on estimates from previous research using data from southwestern Ontario and Halton Region by Hambly et al. (2019, 2020).[48] While private benefits of telecommuting can vary depending on the job, region, and patterns of transportation, etc., mid-range estimates suggest that a rural telecommuter can save around $8000 in transportation costs per year. As in the case of foregone property value gains from sub-par broadband discussed above, the potential benefit to individual telecommuters is higher than per household deployment costs of high-quality FTTP in rural areas, for instance EORN's estimated $4000-$6000 per household in rural eastern Ontario. Some potential telecommuters may be willing and able to pay a hefty connection fee to gain access to reliable fibre service to enable their teleworking. Market forces can fail to account for the private benefits because not everybody is a telecommuter and the average willingness to pay can be much lower than the rural telecommuter's surplus (i.e. neighbours only willing to pay on average $80 to $120 per month, or ~$1,000 per year for adequate broadband on legacy platforms).

**Private and public benefits of telecommuting**

| **Assumptions** | Mid-range | Low | High |
|---|---|---|---|
| Annual cost savings to teleworker | 7600 | 6700 | 8500 |
| $CO_2$ reduction per teleworker (kg, annual) | 2450 | 2200 | 2700 |
| Teleworking Capacity | 40 | 10 | 75 |
| Population in target area | 600000 | | |
| Employed/potential workers in target area | 250000 | | |
| % Teleworking beyond COVID | 20 | 10 | 30 |
| **Estimates** | | | |
| **Telecommuters in region** | 50000 | 25000 | 75000 |
| Private cost avoidance/savings (annual) | **380,000,000** | **167,500,000** | **637,500,000** |
| $CO_2$ emission avoidance (kg) | 122,500,000 | 55,000,000 | 202,500,000 |
| Public benefit: Per capita emission reduction from region (kg) | 204 | 92 | 338 |

The low-range estimates above suggest that increasing telecommuting by about 10% will generate private benefits to rural telecommuters in eastern Ontario of around $50 million per year. Over a 10 years period, the benefit would be sufficient to offset about one third of capital expenditures required for the EORN Gig model if the positive spillovers could be internalized (an amount just about the same as the difference in subsidies required for EORN basic service vs. Gig models). In

[48] http://www.r2b2project.ca/ ; Hambly, H., & Lee, J. D. (2019). The rural telecommuter surplus in Southwestern Ontario, Canada. *Telecommunications Policy*, *43*(3), 278-286. https://www.sciencedirect.com/science/article/pii/S0308596118301046

the mid-range case, the private cost savings over 10 years from 20% of workers in the Region telecommuting would be about equivalent to the estimated subsidy required for Gig model of $1.2 billion.

This private cost avoidance is complemented with a public benefit that also remains uncaptured in the presence of market failures as less telecommuting reduces household greenhouse gas emissions as well. This amounts to around a per capita reduction of $CO_2$ emissions of about 100 kg per year in our pessimist case and 350 kg per year in the optimist case. Given per capita emissions in Ontario were about 3.7 tonnes a year before COVID, potential reductions from building a broadband infrastructure enables emission reductions through telecommuting is significant.[49]

It is important to note here that in addition to enabling work from home, reliable fibre optic access networks are substantially less power hungry/greener than other fixed broadband technologies and wireless. Wireless networks tend require about 10 times more power than wired networks.[50] With various wired technologies, fibre optic access networks have by far the lowest energy consumption requirements (about one 10th of coaxial cable and one 5th of DSL).[51] Targeting public broadband subsidies to encourage the transition from copper/DSL to fibre optics and reducing reliance on wireless would have hard to capture positive spillovers in terms of pollution reduction as more people work and go to school from home and demand more bandwidth.

#### *3.3.3. Home-based healthcare and healthcare costs*

Broadband access is increasingly recognized as a social determinant of health.[52] As in the case of telecommuting, COVID has demonstrated that a wider range of healthcare services can be delivered remotely, without significant loss in quality of service. Some healthcare applications do not necessarily require very high-speed/low latency broadband (e.g. ordering medicine, talking to the doctor). The functionality of other advanced applications that enable home monitoring and home-based healthcare delivery depend on reliable connectivity that is hard to deliver on other wired and wireless technologies besides low-latency fibre. Previous research suggests that in addition to be benefits of home healthcare applications for people that tend to require relatively

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[49] https://www150.statcan.gc.ca/n1/daily-quotidien/190123/dq190123d-eng.htm

[50] Baliga, J., Ayre, R., Hinton, K., & Tucker, R. S. (2011). Energy consumption in wired and wireless access networks. *IEEE Communications Magazine*, *49*(6), 70-77. https://people.eng.unimelb.edu.au/rtucker/publications/files/energy-wired-wireless.pdf

[51] Aleksic, S., & Lovric, A. (2011). Energy consumption and environmental implications of wired access networks. Am. J. Eng. Applied Sci, 4, 531-539. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1001.1481&rep=rep1&type=pdf

[52] Benda, N. C., Veinot, T. C., Sieck, C. J., & Ancker, J. S. (2020). Broadband Internet Access Is a Social Determinant of Health!. *American Journal of Public Health*, *110*(8), 1123-1125. https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2020.305784

more monitoring and health care services, fibre enabled home-healthcare delivery can have significant cost reduction implications for healthcare delivery in rural areas.[53]

The following table uses estimates from rural municipal case studies in Sweden on the economic benefits of FTTP enabled home healthcare applications to capture potential gains in terms of healthcare cost reduction associated with the EORN Gig model. Low diffusion/use state in the table reflect the case where about 10% of the population in a rural municipality with fibre are using advanced home health care applications it enables, while the high diffusion/use case reflect heavy reliance with 90% of the population connected to the healthcare system via advanced applications that require high-quality broadband. According to data from the Canadian Institute for Health Information (CIHI), total public and private per capita healthcare spending in Ontario stood at about $7000 in 2019, a figure that is undoubtably going to be much higher in 2020 and beyond. Using this benchmark and per capita cost reduction estimates from rural Sweden, enhanced reliance on home healthcare applications that require high-quality broadband infrastructure have the potential to reduce healthcare costs between 1% in the low diffusion and up to 7% in the high diffusion models.

**Healthcare system cost savings from growth in FTTP enabled home-healthcare applications**

| **Assumptions** | Mid-range | Low diffusion/use | High diffusion/use |
|---|---|---|---|
| **Number of residents in target area** | 600000 | | |
| **Per capita healthcare expenditures** | 7000 | | |
| **Per capita cost reduction** | 285 | 60 | 510 |
| **Estimate** | | | |
| **Total healthcare costs in region** | 4,200,000,000 | | |
| **Healthcare cost avoidance (annual)** | 171,000,000 | 36,000,000 | 306,000,000 |
| **% reduction** | 4% | 1% | 7% |

The low diffusion/use scenario above can be interpreted to reflect potential impacts of adopting the approach in the EORN basic service model, where there is some expansion of fibre access networks and service quality grows incrementally. Increasing use of advanced homebased applications in this state by about 10% could be expected to generate a 1% reduction in healthcare costs. At the other extreme, with full fibre diffusion envisioned in the EORN Gig model that

[53] Forzati, M., & Mattsson, C. (2014, July). FTTH-enabled digital home care—A study of economic gains. In 2014 16th International Conference on Transparent Optical Networks (ICTON) (pp. 1-7). IEEE. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1041.9141&rep=rep1&type=pdf

enables significant take up and use of home healthcare applications can help reduce total healthcare spending by up to 7%. Our mid-range estimates suggest that the combined public and private benefit in terms of healthcare cost avoidance in the Region could potentially amount to $170 million per year in healthcare cost savings. Over a 10 year period post deployment period, potential cost avoidance from information intensification and remote healthcare delivery requiring high-quality broadband has the potential to cover the entire fixed capital cost expenditures requirements of the EORN Gig project.

It is relevant to note that with COVID, both patients and healthcare service workers have strong incentives to avoid personal contact and intensify their use of Internet-based applications. Consequently, the high-diffusion state outcomes become more likely if healthcare providers and the provincial government intensify their efforts to expand access and use of remote healthcare delivery methods, particularly in rural areas where it is hard to find healthcare practitioners and access related resources in person. This is particularly relevant for healthcare delivery to older adults and others with limited mobility and resources.

### 3.4. Short vs. Long Term Employment Effects

**Short term construction/deployment impacts:** Proposed regional broadband infrastructure improvement initiatives will have a transitory positive impact on employment during the deployment phase by increasing demand for engineering, construction, and related services. This is particularly relevant when we consider the recession caused by COVID and demand for fiscal stimulus. The EORN Gig model will cost between 2 to 3 times more to construct compared to the EORN basic service model and will involve significantly more fibre construction (50,000 vs. 15,000 km) in areas of the Region with relatively high wireline deployment costs. Consequently, as economic stimulus the EORN Gig model is likely to have a proportionately larger impact in helping sustain employment in telecom and construction sectors than the basic service model.

The subsequent table provides estimates the potential impacts of the project models in sustaining (and potentially creating) jobs using a variety of different estimated job multipliers for telecommunications network construction and engineering in Canada, Ontario, and Region. In addition, we use generic estimates of the impact of public infrastructure spending in Ontario that help segment the impacts and cross-check the validity of estimates based on industry specific employment multipliers.[54] Our mid-range estimates suggest that the EORN Gig model will help

[54] In particular, estimates compiled for the Ontario Government in the development of Ontario's Long Term Infrastructure Plan (2017). See: Centre for Spatial Economics (2017). The Economic Benefits of Public Infrastructure Spending in Ontario. Report Commissioned by the Government Ontario. http://qedinc.ca/wp-content/uploads/2018/08/Ontario-Public-Infrastructure-2016-Final-Report.pdf
The Conference Board of Canada (2013) The Economic Impact of Ontario's Infrastructure Investment Program.

sustain and/or create around 12,000 full-time equivalent jobs during the deployment stage (divided over however number of years it will take to build). The vast majority of these jobs will be in Ontario, with limited spillovers in other areas of Canada. Based on sector specific regional multipliers compiled by EOLC, we estimate that between a third and quarter of the total jobs sustained/created in this phase will be create within eastern Ontario (~3,300 in region out of ~12,000 total).

| **Short term construction impacts on employment and tax revenue** | | | |
|---|---|---|---|
| **Assumptions** | Mid-range | Low | High |
| CAPEX Gig design (million) | 1600 | | |
| CAPEX 50/10 design (million) | 730 | | |
| Jobs (full time equivalent jobs per $ million) | | | |
| National (Statistics Canada) | 7.35 | 6.3 | 8.4 |
| Ontario (LTIP(2017)) | 7.05 | 4.7 | 9.4 |
| Eastern Ontario (EOLC) | 2.1 | 1.7 | 2.3 |
| **ON + Fed tax revenue from infrastructure spending (per million $)** | 0.32 | 0.27 | 0.37 |
| **Estimates: Employment** | | | |
| **Gig model** | | | |
| In Canada | **11760** | 10080 | 13440 |
| In Ontario | **11280** | 7520 | 15040 |
| In Region | **3360** | 2720 | 3680 |
| **Basic service/50/10 model** | | | |
| In Canada | **5366** | 4599 | 6132 |
| In Ontario | **5147** | 3431 | 6862 |
| In Region | **1533** | 1241 | 1679 |
| **Estimates: Upper-tier tax revenue from construction phase** | | | |
| **Gig model** | **512** | 432 | 592 |
| **Basic service/50/10 model** | **234** | 197 | 270 |

Expected job impacts from the less capital intensive/cheaper EORN basic service model design are expected to be proportionately lower, as will be the expected taxes upper-tier governments can expect to recover from sustaining and creating employment by investing in the higher capital intensity Gig model. Using tax revenue generation estimates from previous public infrastructure spending growth in Ontario, we estimate how much of the spending will be recovered by upper tier governments via income and other taxes. Our mid-range estimates suggest that the

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https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiQ7IWchOHrAhXohHIEHZ84DF0QFjAAegQIBBAB&url=https%3A%2F%2Fwww.infrastructureontario.ca%2FWorkArea%2FDownloadAsset.aspx%3Fid%3D34359739996&usg=AOvVaw2EYgBJB2aW9R7eN7bx3A6v

construction/deployment phase of the $1.6 billion Gig project will generate around $500 million in tax revenue in the short to medium term.

**Medium to long term spillovers:** There are significant uncertainties about the employment impacts of better broadband. On the one hand, better broadband increases both capital and labour productivity, which may lead to demand for less labour by existing businesses as they substitute capital for labour. Better broadband can also allow local businesses to procure some of the labour and services they need from far away places, reducing their need for local labour. On the other hand, better broadband can attract new businesses and enable entrepreneurship in rural areas and isolated communities by collapsing their “distance” to regional and global markets. This would have a positive impact on employment. The answer to the question if better broadband increases or decreases prospects for employment is theoretically ambiguous and needs to be answered empirically. While some studies have found a strong positive impact from ultra-high capacity FTTP networks on indicators of local employment (and negative impact on unemployment), others have found very small and/or statistically insignificant employment impacts from broadband.[55] Our review of the research literature did not identified any studies that found a statistically significant negative impact from broadband improvements on indicators of employment/unemployment in rural areas.

[55] Katz, R. L., Vaterlaus, S., Zenhäusern, P., & Suter, S. (2010). The impact of broadband on jobs and the German economy. Intereconomics, 45(1), 26-34. https://www.intereconomics.eu/contents/year/2010/number/1/article/the-impact-of-broadband-on-jobs-and-the-german-economy.html
Ivus, O., & Boland, M. (2015). The employment and wage impact of broadband deployment in Canada. Canadian Journal of Economics, 48(5), 1803-1830. https://hosted.smith.queensu.ca/faculty/OIvus/docs/articles/Ivus_Boland_CJE_2015.pdf
Singer et al. (2015) The Empirical Link Between Fibre-to-the-Premises Deployment and Employment: A Case Study in Canada. Bell Canada GiC petition. https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/TRP-CRTC-2015-326-Bell-Canada-Attachment3.pdf/$file/TRP-CRTC-2015-326-Bell-Canada-Attachment3.pdf
Hasbi, M. (2017). Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence. In 14th ITS Asia-Pacific Regional Conference, Kyoto 2017: Mapping ICT into Transformation for the Next Information Society (No. 168484). International Telecommunications Society (ITS). https://www.econstor.eu/handle/10419/168484
Nordin, M., Grenestam, E., & Gullstrand, J. (2019). *Is Super-Fast Broadband Negative? An IV-Estimation of the Broadband Effect on Firms' Sales and Employment Level* (No. 2019: 8). https://project.nek.lu.se/publications/workpap/papers/wp19_8.pdf

| Medium to long term employment impacts of expanding FTTP in rural eastern Ontario | | | | |
|---|---|---|---|---|
| **Assumptions** | Mid-range | Low | High | Source/note |
| Premises to be served with FTTP (count) | 250,000 | | | EORN model estimates |
| Population in target area | 600,000 | | | 50% of region |
| Local employment growth from ultra-high capacity/FTTP deployment | 1.5 | 0 | 3 | Singer et al./Bell Aliant FTTP deployments (2015); literature review |
| Local self employment growth from NGN | 1 | 0 | 2 | Hasbi, M. (2017); French municipalities; literature review |
| Local unemployment reduction from NGN | 3.5 | 0 | 7 | Hasbi, M. (2017); French municipalities; literature review |
| Employed in EO underserved area (as of Jan 2021 | 240,000 | | | EOLC; Assuming 50% employment rate with COVID, ~10% below usual |
| Unemployed in underserved area (as of Jan 2021) | 50,000 | | | EOLC; Assuming 10% unemployment; ~5% above usual |
| Self employed in target area | 41000 | | | EOLC; Note: number of self-employed declined by 7% in EO between 2016-2019 |
| Income tax per job per year | 6800 | 5600 | 8000 | Estimated at 20% rate of mid point between ON average and minimum wage rates |
| EI/income support benefits to unemployed | 24000 | | | At $2000 per month |
| **Estimates** | | | | |
| Additional jobs | 3600 | 0 | 7200 | COVID makes high end estimates based on historical data more likely for EORN Gig model, and low end/no impact for 50/10 model |
| Additional self employed | 410 | 0 | 820 | |
| Total in region employment impacts | **4010** | 0 | **8020** | |
| Additional income tax for upper tiers from EO (annual) | 27,268,000 | 0 | 64,160,000 | |
| Fewer unemployed | -1750 | 0 | -3500 | |
| Lower EI/income support for EO residents (annual) | -42,000,000 | 0 | -84,000,000 | |
| Summary budget impact ($, million; annual) | **69** | | 148 | |
| Budget impact over 10 years (5-15 years post deployment) | **690** | | 1480 | Assuming income taxes don't increase |

Given that the incremental basic service model is designed to make only a basic level of service available, we do not expect it to have a significant positive impact on employment. For the impact of the EORN Gig model, we use an impact elasticity of zero as the lower bound for the estimates outlined in the table below, taking available range of positive effect estimates on employment from existing studies as our upper bound/best case scenario. In particular, we use baseline estimates from Singer et al. (2015) based on proprietary Bell Aliant FTTP deployments as our upper bound for potential spillover jobs effects (~3%), as well as elasticities estimated by Hasbi (2017) based on data on diffusion of ultra-high speed fibre connections in French municipalities. As for labour market size assumptions for the underserved areas EORN plans to target, we have obtained information on the number of employed and self employed in the Region from EOLC. We incorporate the sharp negative impact of COVID on employment rates into the baseline we use (-10% reduction in employment rate as of the latest data). Our baseline assumptions about the level of employment may, or may not, be reasonable depending on uncertainties about where the COVID and the recession will take us by the time the FTPP deployments are completed and employment impacts of better broadband start to materialize with increased uptake and usage.

Based on our mid-range assumptions, we estimate that post deployment and a ramp up phase in take up, all else equal, the EORN Gig project will generate an additional 4000 jobs in eastern Ontario. Using relatively conservative assumptions about wages from these jobs and income tax rate at that level, we estimate that these jobs will generate an additional $27 million annually in income taxes to upper tier governments. In addition, data from French municipalities analyzed by Hasbi (2017) suggests that ultra-high speed/fibre-based broadband diffusion can have a negative impact on local unemployment rates. Assuming monthly unemployment benefit/income support costs of about $2000 per month per unemployed person and a mid-range unemployment reduction impact of 3.5% from FTTP deployments, we estimate that the Gig project has the potential to reduce demand for unemployment/income support by about $42 million annually in the medium to longer term.

**Summary of employment and budget impacts:** Combining the long term effects on employment/unemployment with the short term construction impacts under our mid-range assumptions, suggests that the total amount of taxes upper tiers governments can expect to recover from investing in the EORN Gig project can add up to around $1.2 billion 10 to 15 years after the start of construction. This is broadly comparable to the total public investment EORN estimates the Gig project will require. In the case of the EORN basic service design, increased employment and tax recovery will be limited primarily to the construction impacts over the first 5 years of the project. This is because the basic service model is not designed to reduce relative gaps in broadband infrastructure quality between rural eastern Ontario and urban centres. In other words, our estimates suggest the Gig model is capable of enabling full tax recovery over time, but the basic service model may not support sufficient growth to ensure upper-tier governments can recover the required initial investments.

### 3.5. GDP and General Tax Impacts

The analysis in previous sections tries to quantify particular channels through which ultra-high speed/fibre optic networks may generate economic value through a combination of public and private benefits. The opportunity costs of technological sclerosis and poor broadband appears extensive particularly from the perspective of consumers with demand for high-quality connectivity that need to telecommute, obtain healthcare services, and increasingly rely on online education. The benefits outlined in previous sections are not necessarily additive, but some of them can be viewed as complementary. For example, property values increase in areas that have relatively good employment opportunities, which are both positively correlated with broadband infrastructure quality. These factors tend to reinforce each other and questions of causality vs. correlation remain. In this concluding section, we take a more macrolevel perspective and evaluate the potential impacts of the EORN Gig project on regional GDP and growth in overall government tax revenue in the medium to longer term. To ensure the robustness of the results, we use two distinct methods for quantifying the estimated impacts on GDP levels and tax revenue growth:

**Method 1: Ultra-high speed (+100 Mbps)/fibre diffusion elasticities on GDP from international studies**

The primary method we use to estimate the GDP impact of the EORN Gig project is based on estimates from previous empirical research on the impact of growth in broadband speeds and diffusion of ultra-high capacity fibre networks in high income countries on GDP.[56] Our literature

[56] Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2011). Broadband infrastructure and economic growth. The Economic Journal, 121(552), 505-532.
https://www.econstor.eu/bitstream/10419/30590/1/615363539.pdf
International Telecommunications Union (2012) Impact of Broadband on the Economy.
https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf
Kongaut, C., & Bohlin, E. (2014). Impact of broadband speed on economic outputs: An empirical study of OECD countries. In 25th European Regional ITS Conference, Brussels 2014 (No. 101415). International Telecommunications Society (ITS).
https://www.econstor.eu/bitstream/10419/101415/1/795234465.pdf
Analysis Group (2015) Early Evidence Suggests Gigabit Broadband Drives GDP.
https://www.analysisgroup.com/globalassets/content/insights/publishing/gigabit_broadband_sosa.pdf
Lüdering, J. (2016). Low latency internet and economic growth: A simultaneous approach (No. 34-2016). Joint Discussion Paper Series in Economics.
https://www.uni-marburg.de/fb02/makro/forschung/magkspapers/paper_2016/34-2016_luedering.pdf
Hasbi, M. (2017). Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence. In 14th ITS Asia-Pacific Regional Conference, Kyoto 2017: Mapping ICT into Transformation for the Next Information Society (No. 168484). International Telecommunications Society (ITS).
https://www.econstor.eu/handle/10419/168484
WiK Consult/Ofcom (2018). The Benefits of Ultrafast Broadband Deployment.
https://www.ofcom.org.uk/__data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf

review did not find any Canadian specific studies in this area. International studies suggest a relatively large range in estimates of the links between broadband and economic growth. Overall, previous work suggests that the transition from basic broadband to ultra-high capacity broadband can increase GDP levels by about 1%. However, the GDP impact is relatively limited impact in some countries and a much larger one in others (i.e. larger where FTTP is extensively deployed and used widely; e.g. Korea, Japan, Sweden). In other words, the macro level impacts depend on capacity of the economy to take advantage of the wide range of productivity enhancing Internet applications and services that reliable connectivity enables people and businesses to use.

The following table provides estimates of the potential impacts of the EORN Gig project on GDP and taxes in rural eastern Ontario. Based on mid-range estimates from previous empirical research on the impact of the diffusion of ultra-high speed broadband on productivity growth and GDP, we estimate that the EORN Gig project will lead to an increase in regional GDP level by about $300 million post deployment and an initial productivity growth uptick phase. Assuming a 33% tax to GDP ratio Canada has today does not change too much in the future as deficits grow, GDP growth from expanding fibre access networks will increase the overall level of taxes from economic activity in rural eastern Ontario associated with the Gig project by about $100 million a year once broadband induced GDP growth levels off 5 to 10 years post deployment.

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| GDP and tax revenue impacts of EORN Gig Project<br>Method 1: Using ultra-high speed/FTTP specific impact elasticities | | | | |
|---|---|---|---|---|
| **Assumptions** | Mid-range | Low | High | Source |
| Premisses to be served with FTTP (count) | 250,000 | | | EORN model estimates |
| Population in target area | 600,000 | | | 50% of region |
| Per Capita GDP pre-COVID | 58000 | | | ON MoF |
| GDP in target area baselines | | | $35 billion | Assuming recovery by the time network deployed |
| Tax to GDP ratio | 33% | | | OECD (33% in 2018; will likely increase in the future) |
| Ultra-high speed (+100 Mbps/FTTP) impact on GDP | 0.8% | 0.4% | 1.20% | Literature review; total impact to materialize post deployment and persist in medium to longer term |
| **Estimates** | | | | |
| Regional GDP with full FTTP diffusion (billion) | 35.280 | 35.140 | 35.420 | |
| Additional GDP per year (million) | **280** | 140 | 420 | Post deployment and ramp up phase (3-5 years) |
| Additional tax per year (million) | **92** | 46 | 139 | |
| 10 year total GDP impact (up to) | **$3 billion** | | | Implied multiplier of 2.5; which is close to LTIP lower bound baseline of 3 |
| 10 year total tax revenue impact (up to) | **$1 billion** | | | |

## Method 2: Cross check with GDP impact estimates using generic public infrastructure spending elasticities/multipliers in Ontario

In addition to using broadband specific elasticities to estimate economic impact of the EORN Gig project, we can utilize general public infrastructure spending multipliers in Ontario to evaluate GDP and tax impacts of public broadband infrastructure across different time horizons. The distinctiveness of this approach from the Method 1 above allows for triangulation of the estimates and validating the robustness of the results. We use two sets of Ontario specific estimates of public infrastructure spending impacts on GDP. The first set of impact multipliers is based on retrospective analysis of Ontario public infrastructure investments between 2006 and 2014, while the second set was estimated as part of the process to develop Long Term Infrastructure Plan (2017).[57] These estimates help account for positive spillovers from public infrastructure investment on private capital formation over different time horizons.

**Short to medium term GDP impacts:** General infrastructure multiplier estimates for Ontario suggest that every $ spent increases GDP by between $0.91 and $1.14. For the public investment of $1.2 billion in the EORN Gig project, this translates to a GDP gain of between $1.092 and $1.37 billion over the short to medium term from the construction and deployment fiscal stimulus effect. At the GDP to tax ratio of 33%, the total tax recovery from the deployment phase of the project is estimated to be $400 to $450 million. Notably, this tax recovery impact based on generic infrastructure multipliers for the construction phase is consistent with those derived based on broadband to GDP specific elasticity measures from the research literature used in Method 1 over a 5 year period (i.e. $92 million x 5 = $460 vs. $400-450 million). Given the distinctive assumptions and approaches in Method 1 and Method 2, the fact that they generate broadly consistent results on tax recovery suggests the validity of the estimates.

| **GDP and tax revenue impacts of EORN Gig Project<br>Method 2: Using generic Ontario public infrastructure spending multiplier estimates** | | | |
|---|---|---|---|
| Estimated public investment | **$1.2 billion** | | |
| | Mid-range (medium to long term) | Short-medium term | Long term (up to 2050) |
| **a) Generic infrastructure/GDP multipliers for ON (per $ invested)** | | 1.14 | |
| GDP impact ($ billion) | | **1.37** | |
| Tax revenue | | 0.45 | |
| | | **$450 million** | |
| **b) Generic infrastructure/GDP multipliers for ON (per $ invested)** | 2 | 0.91 | 3 to 6 |
| Total GDP impact ($ billion) | **2.4** | 1.092 | 5.4 |
| Additional taxes at 33% tax to GDP ratio | 0.792 | 0.36036 | 1.782 |
| | **$800 million** | **$400 million** | **$1.8 billion** |

[57] The Conference Board of Canada (2013) The Economic Impact of Ontario's Infrastructure Investment Program. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiQ7IWchOHrAhXohHIEHZ84DF0QFjAAegQIBBAB&url=https%3A%2F%2Fwww.infrastructureontario.ca%2FWorkArea%2FDownloadAsset.aspx%3Fid%3D34359739996&usg=AOvVaw2EYgBJB2aW9R7eN7bx3A6v
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**Medium to long term:** Trying to predict GDP and government revenue generation possibilities beyond the short to medium term is more challenging and error prone due to growing uncertainties as the time frame for the analysis gets longer. Based on mid-range generic infrastructure spending estimates in Ontario, we can estimate that the EORN Gig project will lead to an increase in GDP of $2.4 billion over the medium to longer term as it generates additional private investment and positive externalities/efficiency gains start to translate into measurable GDP growth (i.e. 5-10 yeas post deployment). Expected government revenue from this can add up to around $800 million under mid-range assumption and just under $2 billion in the optimistic case (i.e. high diffusion, high take up and use case). The mid-range estimate of $800 million using generic multipliers in Method 2 is 20% lower than the estimate of $1 billion in tax recovery over the post deployment decade in Method 1. This is pretty close, further validating the results of the approaches used here to quantify the macro level impacts of full fibre deployment in underserved parts of eastern Ontario. The optimistic case under Method 2 generates a significantly larger GDP and government revenue generation impact, partly because it is based on very long-term infrastructure impact estimate for Ontario (up to 2050 at 2.5% discount rate).

**Robustness/validity:** While impacts estimated with broadband/fibre specific elasticities above are somewhat higher than with generic infrastructure impact estimates for Ontario (implied medium/long term multiplier of 2.5 vs 2), the resulting estimates are broadly consistent. Given the distinct methodologies used for the two classes of estimates, this suggests the robustness of the resulting summary estimates of the impact of the EORN Gig project impact on GDP, as well as prospects for recovering the public investments 10 to 15 years post deployment.

***End of Document***