

Eastern Ontario Regional Network

Increasing Returns, Productivity, Externalities, and Monitoring

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Introduction

The technological nature of the Eastern Ontario Regional Network's Gig Project has significant economic aspects that must be taken into account for the potential economic growth and productivity advantages that are associated with it to be realized. The nature of the technology also makes it necessary to collect baseline data across the communities of eastern Ontario, and to monitor the outcomes from the adoption of the technology, so that positive economic outcomes from the underlying economic characteristics of the Gig technology can be used to the communities' greatest advantage. By establishing the baseline characteristics of the communities and monitoring the paths communities take with the adoption of Gig technology, the impacts of the Gig Project can be used as a model for the adoption of Gig technology in rural communities across Ontario, and Canada.

The Gig Project technology offers the ability to address the increasingly significant negative consequences of COVID-19 for rural communities. Fortunately, the nature of Gig technology has associated economic factors that can better support economic growth and productivity improvements that do not exist with 50/10 technology.

While 50/10 technology is the most common today, the next wave of technology is fibre optic, Gig technology. There are several technical aspects of Gig technology that make it superior and longer lasting than 50/10 technology. At least as important as the technical advantages of Gig technology are the important economic advantages that come with the more advanced technology. The economic advantages of Gig technology are both qualitatively and quantitatively superior to that of 50/10 technology.

The Advantages of Increasing Returns Technology Over Diminishing Returns Technology

An important difference between 50/10 and Gig technology is that Gig technology has twenty times the capacity of 50/10. This presents a significant difference in terms of the capacity of two technologies to support economic growth.

In the early stages of the adoption of 50/10 technology by households and businesses, its capacity allows for a significant increase in usage with small incremental costs. However, as usage becomes more intense, the capacity of the technology to process higher volumes of activity eventually diminishes. In economic terms, 50/10 technology exhibits increasing returns in the short term, however, as its adoption becomes more prevalent, the capacity of the technology is challenged, the increasing returns eventually disappear, and diminishing returns set in for any increases in usage. That

is, as the adoption of the 50/10 technology grows, the inputs required to satisfy the growing usage will be greater than the output it can support – diminishing returns.

With decreasing returns, cost functions are U-shaped. Increasing returns exist when costs are declining; diminishing returns exist when costs are rising. The level of output where costs are at their minimum – where increasing returns turns into diminishing returns – is the most economical level of production. That is, once the increasing returns have been depleted, there is little incentive to significantly increase production. Therefore, businesses relying on 50/10 technology will reach a point where there is little economic incentive to grow their business because of the diminishing returns. With Gig technology, the capacity is so much greater that are economic incentives to grow the business because of increasing returns. Overall, 50/10 technology constrains economic growth; Gig technology promotes economic growth.

Gig technology is representative of a growing number of new technologies that exhibit persistent increasing returns. This is an important shift in methods of production from the dominant technologies of the past. Production in most of the industries that grew significantly in the nineteenth and twentieth centuries – e.g., agriculture, mining – exhibited diminishing returns. However, more production technologies have recently exhibited increase returns. For technologies that require large initial, development investments due to the knowledge-based nature of the technology, and the economies that come from learning as the development and usage increases, the additional costs of providing more usage declines, persistently. Therefore, many new technologies, for instance, in computing, telecommunications, and fibre optics exhibit increasing returns in the short- and long-term.

Most importantly, the adoption of technologies under different technological regimes (i.e., diminishing returns versus increasing returns) leads to very different results. This difference is very significant for the adoption of Gig technology across eastern Ontario. The adoption of Gig technology across the communities will lead to different results in each community. That is, because of increasing returns there will be no convergence toward a common outcome as the existence of diminishing returns would.

Path Dependencies

In a diminishing returns regime, the long-term state is characterized by the convergence toward a single, steady-state equilibrium. In an increasing returns regime, there is no convergence toward a single steady-state result. For the Gig Project, this means that as the adoption of the technology increases, each community will take different paths toward different outcomes. That is, there will be divergent outcomes associated with increasing returns, rather than the convergent outcomes that is common under diminishing returns. Whereas under a diminishing returns regime the path taken by each community would be subjected to similar economic forces, under increasing returns, the path taken by each community will be influenced by the economic circumstances of each community when the technology begins to be adopted, and other factors that impact the technology as its adoption increases. Therefore, it is important to consider the *path dependent* nature of increasing returns as access to Gig technology increases across eastern Ontario.

The paths communities will take will be influenced by the initial conditions that exist in the community – e.g., the economic sectors that are predominant in the community, the degree to which technologies

other technologies have been adopted in the past, the level of technological expertise in the community. Also, impacts from events related to the technology's adoption influence the path that will be taken. Events early in the adoption process will have greater impact on the path taken than the events that occur further along the path.

Due to the significance of *path dependencies* increasing returns regimes, it is important to document initial conditions and the types of factors that will influence the potential paths communities will take as the Gig technology is being put in place. This will be the starting point for monitoring across eastern Ontario that will help determine how to best influence the paths being taken to ensure positive outcomes. The importance of *baselining* and *monitoring* as the technology is being rolled out and its adoption will be crucial to the success of the Gig Project and will offer important lessons for the adoption of Gig technologies in other communities.

Positive Feedbacks

Along with path dependencies that come with the increasing returns, Gig technology, there are *positive feedbacks* that influence the outcome of the technology's adoption. Increasing returns are not limited to the sole user of the technology; the advantages can also benefit others. Positive feedbacks are particularly important in an increasing returns regime because as the adoption by individuals, households, and firms grows, because the network of users grows, and does not diminish the capacity of the users to expand their social and economic networks facilitated by the technology.

Positive feedbacks can be beneficial for small business development in rural communities. As the technology is increasingly adopted, the networks – including access to new markets – grows faster than the adoption of the technology. Therefore, the extent of the market expands, making small businesses that adopt the technology able to grow their market niche through the ability to expand their regional business opportunities and to venture into serving more distant markets. Similarly, the disproportionate growth in social and economic networks, expands access to information, access to new ways to use the technology through learning from others, and fuels innovation.

Positive feedbacks also expand the network for growth in the delivery of education, health care, government services, etc. It is through the technology's increasing returns that rural communities could pursue economic opportunities that were unavailable to them in a diminishing returns regime that required larger, optimal size to be profitable and to expand its market reach.

Productivity

Gig technology with its inherent increasing returns, has a much greater potential impact on productivity than the diminishing returns characteristics of 50/10 technology. This is due, in part, to the *positive feedbacks* that come with increasing returns. The ability to expand access to markets, information, education, etc. consistently increases disproportionately to the increase in the costs of getting access to more extensive markets and expanded social and economic networks. That is, the potential increases in output from rural communities due to increasing returns technology, outstrips the necessary increase in inputs required to expand economic activity. This, in itself, provides the opportunity for increasing

productivity in locations that have traditionally been constrained by the lack of access to information, learning, and markets, and because of diminishing returns technologies, limited to small-scale production of goods and services that was often not economically viable.

There is little doubt that the traditional technologies in rural communities will become even less economically viable when urban economies have access to increasing returns technologies and rural economies do not. The ubiquitous impact of technologies like Gig technology in urban environments will make it virtually impossible for rural economies stuck with inferior, diminishing returns technology to compete in terms of the productivity improvement that come with increasing returns technology like Gig-based, broadband access. Without access to reliable, affordable, high-speed broadband in the foreseeable future, the rural/urban divide can only grow even larger.

The impacts of COVID-19 have exposed increasingly concerning disadvantages rural communities because of the increasing necessity of having access to reliable, affordable internet access. The productivity improvement that are being realized from the new workplace – away from the traditional office; toward home offices – is out of reach to most of those living in rural communities. While there are productivity improvements being enjoyed where access to high-speed broadband is common, there are few examples of productivity improvements where access to the technology is poor, or simply unavailable.

Market Failure and Externalities

Market failure exists when important economic factors are not valued in a way that can inform economic decisions. That is, when a social benefit is undervalued, the market will lead to too little of the good or service being produced. There will be a gap between the actual demand for the good or service and the ability of producers to profitably produce and sell it. When the gap is sufficiently large, the private sector will not engage in its production at all – i.e., none of the socially valued good or service is produced.

Market failure is associated with ‘externalities’ – i.e., important factors (both positive and negative) that are external to the market and are not taken into account in making economic decisions. In many cases, externalities are known but not easily quantified, or costed, in economic terms. This is the case for rural broadband technologies. While it is generally accepted that broadband infrastructure is essential to the economic future of, for instance, rural eastern Ontario, the true benefit of the technologies to the communities is unknown and, therefore, not taken into consideration when private-sector service providers make their decisions as to whether they could profitably enter the market to serve consumer needs.

When market failure leads to a significant gap between the social need and the ability of the private sector to enter the market, the public sector often undertakes financial support to the point where the private sector can participate, profitably. This is most often in the case of large infrastructure projects, like the Gig Project, that requires significant spending on infrastructure capital before any sales can be made.

While it has generally been accepted by the public- and private-sector that market failure exists in the broadband infrastructure projects and public-sector financing must lead private-sector investment, the

impacts of the COVID-19 pandemic has exacerbated market failure because of the growing significance of externalities.

With COVID-19, the externalities continue to grow, however, the ability to quantify them, has not. Also, new issues have become part of the growing list of externalities that must be taken into consideration. For instance, attending post-secondary education for students from rural communities had little to do with their access to reliable, high-speed, affordable internet access until the COVID-19 outbreak.

No one expected to need internet access to enable their children 'attend' elementary school classes, or to consult their physician, or to apply for public benefits. COVID-19 has revealed divisions between those who have access to the internet and those who do not. In the COVID-19 crisis and, undoubtedly, in the post-COVID-era, access to the internet is necessary for future economic growth and prosperity for individuals, families, businesses, and communities.

The list of externalities that are widening the internet-access gap is growing, however, they continue to be unaccounted for in private-sector production decisions. The general recognition of these externalities has not led to progress in closing the market failure divide. While there is some quantifiable evidence of the value of associate with externalities, the evidence is more often descriptive than it is quantitative, especially with the short time we have had to develop a comprehensive understanding of the short- and long-term impacts of COVID-19.

Below are several, by no means all, externalities that must be taken into consideration in closing the market failure gaps to provide reliable, high-speed broadband access in eastern Ontario.

Education and Broadband Access:

The COVID-19 outbreak has had an unprecedented technological impact on all levels of education. From children in early elementary school to students in college and university, and academic researchers, access to the internet is now an essential tool for all students and instructors. Not only are classes conducted online, but access to information that is so essential to education requires access to the internet. While this new approach to education is different for everyone – inspiring for some and difficult for others – everyone needs access to the internet to have access to education. More importantly, the lessons learned from the use of new educational technologies will ensure its growing use in the post-COVID-19 era.

Not having access to the technologies essential for education will mean fewer people having access to state-of-the-art education. Those who do not complete high school are generally associated with lower lifetime incomes and standards of living, poorer health, and higher crime rates. All of these factors represent significant social costs. A Conference Board of Canada report (June 2019) concludes that “Our findings suggest that, under a higher graduation rate, Ontario’s government could save an average of \$16.4 million each year – or \$2,767 per additional high school graduate. For the two decades of improved educational attainment in each graduating cohort over 2019 to 2040, that would add up to total savings of \$3.5 billion.” The potential for rural students without internet access to not graduate from high school will grow. Also, lower lifetime learnings from lower levels of education means less spending and lower levels of overall economic activity. The Conference Board finding that “for each \$1.00 increase in public education spending, \$1.30 is generated in economic impacts for the province”

suggests that not investing in broadband technology to facilitate access to education can lead to lower levels of educational attainment and smaller economic impacts from education in the province.

The way in which colleges and universities offer courses and programs will be forever changed by the experiences of COVID-19. High-speed internet, since the COVID-19 outbreak, has become the most common way by which conceptual and theoretical educational material is delivered to students. Access to faculty and information has been accomplished virtually – without entering a campus – very effectively, for those who have access. More importantly, more information is available through online sources when there is access to high-speed internet that is possible in the best traditional, hardcopy, libraries – let alone the libraries of rural communities that have very little access to hardcopy books and, at best, limited access to online books and information through 50/10 technology.

COVID-19 has contributed to an increased likelihood of those not having access to the internet will find it more difficult to achieve educational success. Therefore, the economic costs associated with rural communities not having access to broadband technology, and the increasing degree of market failure making it less likely to be made accessible, will grow more quickly in the post-COVID-19 era, increasing the rural/urban divide.

Women – Employment, Responsibilities for Children, and Broadband Access:

In their investigations of the impacts of COVID-19, StatCan reported that “four in ten (38.9%) Canadian workers are in jobs that can plausibly be carried out from home.” Also, “the COVID-19 pandemic knocked women’s participation in the labour market from a historic high to its lowest level in 30 years.” Even though many women have been given the opportunity to work from home by their employers, their participation in the labour market has significantly declined. The child-rearing responsibilities of women has certainly played a role in this. With the ongoing need for women to have greater child-rearing responsibilities since COVID-19 is due, in part, to changes in the delivery of education and the fewer daycare positions being available.

Without internet access, the ability of women to help with the education of children is limited, and the opportunities to re-engage in the labour market is severely limited by their lack of access to the internet.

With many more jobs being done online in the post-COVID-19 era, women are will find it more difficult to benefit from the recovery if they do not have access to the internet. This represents a loss of the potential output from willing, productive labour across the economy.

“[T]he COVID-19 pandemic knocked women’s participation in the labour force down from a historic high to its lowest level in 30 years.” Should women in rural communities continue to have poorer access to the internet than women in urban centers, rural women will become increasingly disadvantaged in the labour market the longer they do not have access to jobs that require internet access.

Social Determinants of Health:

In August 2020, the American Journal of Public Health published an editorial entitled ‘Broadband Internet Access is a Social Determinant of Health.’ It addresses health issues as they relate to the

sudden necessity for internet access due to the COVID-19 outbreak. All of the issues addressed are relevant to the health implications for those in eastern Ontario in the COVID-19 and post-COVID-19 era. The seven issues addressed are:

- Health care system – with the COVID-19 outbreak, telehealth suddenly became a primary means by which patients connected with physicians. While telephone access is possible for most people, to fully facilitate high-quality virtual visits with a physician requires accessible, broadband access. Without access a patient is disadvantaged in terms of access to health care, and the health care system is compromised in how it can efficiently deliver service.
- Economic stability – broadband internet access has been required for many workers to keep their jobs by working from home after the COVID-19 outbreak. Many workers will not be returning to their traditional workplace in the post-COVID-19 era. Only those with broadband internet access will be able to work virtually. Going back to the traditional workplace for many is no longer possible. The primary means by which those looking for work connect to job openings, and those posting job openings, is through the internet. Those entering the labour market for the first time (e.g., recent post-secondary education graduates) and those looking to return to the labour market are compromised in their search without access to the internet. Also, those trying to file for financial support while unemployed will have a more difficult time getting access to the support if they do not have internet access.
- Education – with all levels of education going online with the arrival of COVID-19, not only is it necessary for students to have access to the internet, but to be effective, there have to be a sufficient number of devices in a household to satisfy the students' needs. Those without broadband internet access (especially at a speed that can deliver large files to different users at the same time), and those households without enough devices will have limited access to education. Along with the issues raised above regarding the economic effects of fewer graduates, this editorial noted that, without access “education experts predict that the pandemic will ‘explode’ already pronounced socioeconomic gaps in educational achievement.”
- Food – online access to facilitate ordering food and having it delivered has been a necessity for many people who are prevented from their traditional grocery habits because of COVID-19 – e.g., health concerns, transportation, lack of a social network to assist them. This puts a vulnerable segment of the population at risk of not having access to food without access to the internet.
- Community and Social Contexts – there are mental health consequences for many of those who have been separated from their social networks due to COVID-19 and do not have access to the online digital tools and social platforms that could be used to maintain contact with their social networks.
- Information – “Access to information is not often considered a social determinant of health but can be considered one now because access to timely, reliable information is critical in the constantly changing environment of a pandemic.” Without access to the internet and timely, accurate information, can lead to detrimental health consequences.

While these points are tied to the COVID-19 virus, it illustrates the growing significance of reliable, high-speed, affordable broadband internet access in supporting people's health. When the most serious consequences of the pandemic have passed, the necessity for broadband internet access will remain. Without the social supports to promote health in place, there will be adverse effects on

mortality, morbidity, life expectancy, health care expenditures, health status, and physical and mental functionality.

The editorial concludes with an important historical perspective which applies to Canada as much as it does to the U.S. We “...emerged from the suffering of the Great Depression with a new commitment to a national safety net to protect the most vulnerable. This [COVID-19] crisis is our opportunity to rethink the concept of the safety net and bring it into the electronic age.”

Access to Information and Markets:

As mentioned in the discussion of the broadband access and the social determinants of health, above, information about job opportunities is most commonly available online. Also, applying for jobs and being interviewed is now commonly done online. Being a job seeker and not having access to the internet is a disadvantage in the labour market.

Similarly, to grow an existing business or to start a new business requires access to information that is difficult to get without access to the internet. The good news is that Gig technology, and the increasing returns it offers, can enable businesses to extend their market without technological constraints – i.e., without the technology, becoming unable to economically cope with expanding their market reach.

The study in France (Hasbi, 2017) revealed that high-speed broadband in local economies expanded entrepreneurs (i.e., most often sole proprietorships) compared to communities without high-speed broadband. This is, presumably, because of the ability to be better informed about market opportunities and to be able to serve and grow sales by extending market reach. That is, access to information and access to distant markets can encourage the growth of small businesses outside urban areas.

High-speed broadband access can also enable local producers of goods and services to replace the goods and services imported from outside the community – i.e., imports from urban businesses to rural customers. With the same access to information for businesses in rural communities as those in urban areas, local businesses can serve the needs of local customers as effectively as they can be imported from urban areas that once had the advantage of network economies in urban areas. That is, the advantage of having access to needed expertise that was once only accessible through face-to-face, or close-proximity networks is now accessible through high-speed broadband access. This is a form of ‘import substitution’ (i.e., one region exporting to another within the same country) that is not limited to the service sector.

New goods production technologies are making it possible for production to be economically undertaken in small batches. That is, large scale production is becoming less necessary to economically, and profitably, produce sophisticated products. New technologies – e.g., 3D printing – can now produce small batches of products in remote locations because of the technology itself, and access to information, online, that can enable the goods to be produced close to the customer. As such technologies become more thoroughly developed and applied, producers in small markets will be able to meet local consumer needs by producing the goods locally. This will require high-speed, broadband technology in small regions, like eastern Ontario. This too, will enable local producers to expand their operations through the use of high-speed broadband technology, and sophisticated production technologies that both exhibit increasing returns.

To be able to produce goods and services efficiently and profitably without having to be in densely populated, urban environments, will encourage workers and businesses to locate outside traditional centres of commerce. High-speed broadband technology is the foundation of a new approach to work/life balance. With the COVID-19 experiences of workers working from home, the success of this in terms of worker productivity and the increasing concern for personal health in densely populated areas, many workers are leaving their homes in urban environments for rural settings, but keeping the same job. This can only happen when the location these workers are moving to areas that have reliable, high-speed, broadband access.

In a 2015 study in the U.S. (Broadband Communities, July 2015) determined that, homes having access to high-speed, broadband internet had values 3.1% higher than homes without such access. Applying this result to eastern Ontario, a home valued at \$225,000 without high-speed, broadband access would increase in value to \$232,000 with high-speed, broadband access. Extending this across the number of homes that will have high-speed, broadband access because of the Gig Project represents a substantial increase in the value of property across eastern Ontario, and an expansion of its municipal property tax base.

Measuring the Baseline, Monitoring Progress, Applying Lessons Learned, and Policy Development

An important aspect of the Gig Project for eastern Ontario is how the economic impacts of the technology can be measured over time. This is particularly important given the increasing returns exhibited by the Gig technology. That is, with increasing returns there is no convergence to one steady-state equilibrium. Rather, various paths, some leading the more economically advantageous and productive than others, will emerge. With this reality comes the need to identify actions that can be taken to contribute to more productive outcomes.

To do this requires an understanding of the initial conditions existing in the communities across eastern Ontario – i.e., the baseline from which the community will change from the introduction of the Gig technology. Also, it is even more important to monitor factors that are identified as central to the Gig technology leading to economic growth and greater productivity.

A study conducted in France in 2017 (M. Hasbi, 'Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence') considered the key factors that having access to high-speed broadband led to positive, local economic effects, including increases in productivity. To assess the economic growth and productivity impacts of high-speed broadband on the creation of new businesses (particularly sole proprietorships as an indication of increasing entrepreneurship), and the impact on unemployment, data related to several key community characteristics were collected. The factors that were used to determine the impacts in different areas of the country included labour market characteristics, the number of households, population density, incomes, levels of education, and the size of the career professional populations in the area. This required establishing the baseline levels of the variables in the models and tracking them over time. Since the impacts come after the introduction of the technology, a three-year lag was incorporated into the models – e.g., beginning the year after the introduction of high-speed broadband into the community, the increase in the number of new businesses would be considered relative to the characteristics of the area three years before. This research could be updated each year to better determine the long-run impacts of the technology.

For eastern Ontario, this kind of research is crucial in determining the historical significance of the characteristics of the communities (i.e., the baseline data) and how key factors influencing economic growth and productivity across different communities change over time. Once baseline data is collected for each community (i.e., being collected as the technology is being put in place), frequent monitoring of key characteristics in each community will allow for the identification of important impacts as each community sets out on a particular grow path (i.e., better understanding the path dependencies of each community) and identifying those actions that can be taken - and when they can be taken - to ensure positive results.

By setting baseline data and regularly monitoring and assessing how access to Gig technology can lead to a better understanding of economic growth and productivity improvements under the increasing returns, Gig technology that can help direct policy as more Gig technology is deployed in other rural communities across Canada.

Conclusions

The *increasing returns* that come with Gig technology and its inherent *path dependencies* and *positive feedbacks*, makes the Gig Project economically superior to the 50/10 technological alternative. 50/10 technology, because of diminishing returns, constrains economic growth; Gig technology with its inherent *increasing returns*, promotes economic growth. *Increasing returns* also facilitates faster responses to the growing economic *externalities* associated with the lack of reliable, high-speed, broadband access in eastern Ontario.

The divide between economic opportunities in urban versus rural communities continues to grow as the disproportionately negative economic impacts of COVID-19 on rural communities, because of the lack of internet access, becomes increasingly apparent. *Market failure* in the building and delivery of high-speed broadband in eastern Ontario requires the participation of the public sector the Gig Project to turn the potential for a vicious cycle of economic decline in the post-COVID-19 era into a virtuous cycle of economic growth and prosperity built on a strong foundation of high-speed, broadband technology.

The Gig Project also provides an opportunity for eastern Ontario to establish the significance of historical, socioeconomic circumstances of each community at the time when high-speed, broadband arrives, and to track the events that create different paths for economic growth as the adoption of the technology expands. Because of the unique nature of *increasing returns* for Gig technology, it is important to track the nature of community *path dependencies* to learn the most significant factors that lead to economic growth. Understanding the baseline and trajectories of communities, especially in the early stages of the adoption of Gig technology, will be instrumental in creating more informed policies for rural economic growth led by high-speed broadband technology in other regions of Canada.