Mobility Network

A University of Toronto Institutional Strategic Initiative

Economic, Social & Environmental Benefits of Transit Investment

A Discussion Paper prepared for the Toronto Transit Commission

Edited By:
Prof. Eric J. Miller & Dr. Judy Farvolden

December 21, 2022

EXECUTIVE SUMMARY

As the TTC and the City of Toronto are determining TTC operating and capital budgets within a context of significant fiscal challenges, it is essential for decision-makers to understand that TTC operating and capital plans represent investments in Toronto's current and future economic competitiveness and in the well-being of current and future residents.

This discussion paper has been assembled by a group of leading researchers within the University of Toronto Mobility Network[1] to demonstrate the assertion above concerning the primary role of public transit as an irreplaceable, essential element of Toronto's physical, economic and social infrastructure. Numerous recent reports and studies have addressed this question from various perspectives, including CANCEA (2020), CUTA (2019), C.D. Howe (Dachis and Godin (2021)) and ITF-C40 (2021), a joint International Transit Federation and C40 Cities report. This paper complements these previous studies by drawing together our collective understanding, based on decades of research, of the fundamental role of public transit in cities in general and Toronto in particular. The paper does this in nine parts, discussing in turn:

- Chapter 1: the fundamental role that investments in the TTC play in the lives and future health and well-being of the residents of Toronto and beyond.
- Chapter 2: the investment challenges and opportunities as incorporated within the current TTC operating and capital budgets.
- Chapter 3: understanding the significant impacts of transit investments on the regional and national economies.
- Chapter 4: understanding Toronto's ongoing evolution, and the role that transit plays, within the regional, national and global economies.
- Chapter 5: the TTC's current position within the Toronto travel market and the large and irreplaceable role it plays in moving people and making Toronto "work".
- Chapter 6: the economic impact of public transit reliability (or lack thereof).
- Chapter 7: the environmental benefits of public transit including reduced greenhouse gas emissions, improved air quality, and better health outcomes.
- Chapter 8: the positive pathways to social connectivity, physical activity, access, and independence and ensuing social and community benefits.
- Chapter 9: findings on the economic, social and environmental benefits of transit investment.

Investment in transit operations has direct economic benefits, enabling job growth and increasing economic productivity and benefits. Toronto, and the Toronto-centred urbanized region of the Greater Toronto-Hamilton Area and Greater Golden Horseshoe, are engaged in a global competition for population, jobs and economic development. We are proud of our global status as a liveable, safe, sustainable city with a vigorous start-up ecosystem, but Toronto has been slipping in world rankings. Investment in public transit generates increased economic

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[1] https://www.mobilitynetwork.utoronto.ca/

activity and opportunity, which, in turn, generates increased demand for transit, which justifies further improvement in these services, which then generate further economic development. Conversely, disinvestment in transit, causing service quality to degrade, is a recipe for Toronto's decline as a place in which to invest and to live.

Investing in the TTC generates broader economic benefits. The TTC is a large economic enterprise, whose operating and capital investments have significant impacts on the regional and national economies, increasing Gross Domestic Product and creating jobs. As documented in detail in Chapter 3 a new analysis of the macroeconomic impacts of investment in the TTC was undertaken for this study. This involved constructing a Multi-regional Input-Output (MRIO) model of the Canadian economy to trace the economic impacts of TTC investment scenarios over the next 15 years on the Ontario and Canadian economies.

Though many simplifying assumptions are inherent in the model, the numbers clearly indicate the very significant impact of TTC investments on the Canadian, Ontario and Toronto regional economies. The TTC is a major "industry" within the economy with, as demonstrated in this analysis, direct economic impact as a generator of economic activity and employment over and above its critical economic, social and environmental impacts as a mover of people within Toronto. TTC investments have at least a net value added of $1 for each dollar invested and are very significant generators or jobs, with approximately half of these impacts estimated to accrue within the Toronto CMA.

The TTC has coped with decades of underinvestment through a combination of efficient operations, a well-designed integrated network of buses, streetcars and subways, and wise investments until the early 1970's. In the 1980's and 1990's the world made pilgrimages to Toronto to learn how to "do transit right". Our failure since the mid-70's to invest in transit at a level commensurate with our growth has damaged the legacy of earlier investments and jeopardized the potential for future growth. These challenges were exacerbated by the massive declines in ridership and revenues during COVID-19 pandemic. While ridership can be expected to eventually return to pre-pandemic levels, the short- and medium-term fiscal challenges for the TTC remain.

Walking and cycling will not get suburban workers to their jobs and their families to stores and services. Transit must provide a cost-effective, attractive, reliable alternative to the private automobile for getting people where they need and want to go. That requires investment in state of good repair and service levels to maintain and upgrade signalling systems, tracks and vehicles to enable reasonable frequencies and speeds, with high reliability. Drivers benefit as much as transit riders from transit investments: every TTC rider is one less driver competing with them for space the city's congested roads. We cannot build enough roads to replace the TTC. The TTC has invested over the past number of years in adding service in high growth areas and to improve service reliability, but these investments in improved service must continue if the TTC is to meet current and expected future needs effectively. In particular, note that the morning peak-period southbound capacity of the TTC's Line 1 subway into the downtown[2] is the equivalent of approximately **26 lanes of highway**. I.e., if Line 1 did not exist, the equivalent of approximately **8-9 additional Gardner Expressways or Don Valley Parkways** would be required to provide the same capacity into the downtown. Clearly this is beyond any notion of feasibility. Thus, without Line 1 (let alone the extensive streetcar and bus network serving the downtown which adds enormous additional people-moving capacity), the Toronto downtown as we know it simply could not exist.

Public transit is essential if the City of Toronto is to achieve its ambitious TransformTO goal to reduce community wide GHG emissions in Toronto to net zero by 2040.[3] The strategy to reduce transportation emissions to net zero states that 75 per cent of school or work trips under 5km are taken by walking, biking or by transit and that 30 per cent of registered vehicles in Toronto are electric. Investment in the TTC plans to decarbonize its fleet will contribute to the City's climate change goals.

The TTC is in the midst of a program to convert its entire bus fleet (including Wheel Trans) to zero emissions by 2040 (TTC, 2020, 2022). Continuing investment in this program is essential to the City of Toronto achieving its TransformTO climate change targets as well as to continue to reduce TTC bus emissions of health-related emissions such as nitrogen oxides and particulate matter.

Every bus converted from conventional "clean" diesel to an electric bus (eBus) results in a 100% reduction in vehicle GHG emissions (93 tonnes/bus/year)[4] and an estimated fuel/energy cost saving of 77% ($40,000/bus/year).[5] Further, to the extent that the TTC is able to attract new riders that are diverted from cars, as discussed above, there are additional environmental and health benefits in terms of GHG and air pollution reductions from the foregone car trips. For more in-depth analysis of the environmental and economic impacts of the Green Bus program, see TTC (2022).

Further, public transit investment is also key to reducing transportation system air pollution and to thereby improving the health of Toronto's population. We spend billions of dollars on health care; proactively reducing a host of health problems from respiratory diseases through to obesity-related illness by investing in maintaining and improving our transit system is another important society benefit.

We are justly proud that one of the most diverse populations in the world calls Toronto home. Public transit is a central component of moving to be the truly inclusive and equitable society to

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[2] Counting both the University and Yonge components of Line 1.

[3] https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/transformto/

[4] TTC (2022). Note that this assumes that the electricity used to power the bus is carbon-free. While Ontario's electricity grid is quite "green", it is not 100% carbon-free.

[5] TTC (2022). This value depends upon the price of both electricity and diesel fuel, both of which can be expected to increase in the future.

which we aspire. Public transit is not the sole solution to this challenge, but, as will be discussed in Chapter 8 of this paper, it is a central component of moving to the truly equitable and inclusive city which is our goal. The TTC's 5 Year Service Plan targets improving transit access to employment opportunities for Neighbourhood Improvement Areas, while a cornerstone of the 2022-2031 Capital Budget and Plan is funding to complete the Easier Access Program, which will see all subway stations fully accessible by 2025.

Since travel is so embedded in everything we do, and transit is essential to moving the millions of people who travel into, out of and around Toronto daily, the total economic, environmental and social benefits of transit system are difficult to isolate. This report begins to explain the magnitude of the role that transit plays in successful global cities.

The essential message of this paper is that public transit, in the case of Toronto, the TTC, is not just infrastructure. The ability to travel to our jobs, schools, entertainments and shopping is fundamental to our quality of life and essential to the functioning of the city itself. The city of Toronto as we know it, and our ambitions for it, would not exist without the extensive, high quality transit system which is the TTC. In challenging times we do need to reduce costs, but in the case of public transit, this could result in long-term, perhaps irreversible, decline in Toronto's national and global economic competitiveness and quality of life. Thus, the picture that this paper has described in detail is one in which investment in public transit infrastructure and services is a "win-win-win" with respect to the economy, the environment and social equity.

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AUTHORS

Editors

Dr. Eric J. Miller is the Principal Investigator on this project.

He is a professor in the Department of Civil & Mineral Engineering at the University of Toronto, the director of Mobility Network at the University of Toronto School of Cities, and the research director of the Data Management Group and of the Travel Modelling Group. His research is centered in the implementation of activity-based travel models for use in operational practice, including the analysis of transit demand. He modelled the transit demand resulting from scenarios on capital investment.

Dr. Judy Farvolden is the Managing Director of Mobility Network at the University of Toronto School of Cities. Through an extensive network of industry and government partners she identifies opportunities to apply the University of Toronto's broad and deep transportation research expertise to realize a future of seamless, integrated mobility that enhances access and equity, and mitigates climate impacts. In 2020-2021 she served on the Toronto Transit Commission Business Transformation Task Force. Judy managed the project internally and liaised with TTC leadership to ensure the timely delivery of relevant and useful research results.

Co-Investigators

Dr. Richard J. DiFrancesco is an associate professor in the Department of Geography & Planning and the department chair. Rick is an economic geographer interested in regional economic development implications of the changing spatial distribution of production caused by the proliferations of global production networks in all sectors of the global economy. Rick built the economic input/output model, analyzed investment scenarios and present the results.

Dr. Marianne Hatzopoulou is a professor in the Department of Civil & Mineral Engineering at the University of Toronto and the Canada Research Chair in Transportation and Air Quality. Her research expertise is in modelling road transport emissions and urban air quality as well as evaluating population exposure to air pollution. Marianne researched the impacts of road transport emissions on health and the environment.

Dr. Willem Klumpenhouwer is a postdoctoral fellow in the Transit Analytics Lab researching transit and rail data analytics, including railway delay analysis, geospatial performance and access on transit systems and on-demand transit. Willem researched the benefits and costs of transit service frequency and reliability. T.

Dr. Matthew Palm is a senior research associate in the Department of Human Geography at the University of Toronto Scarborough and research coordinator of Mobilizing Justice. His research delves into the social impacts, nighttime aspects, and equity dimensions within transportation systems and planning. Matt researched the social and community benefits.

Dr. Matti Siemiatycki is a professor in the Department of Geography & Planning and the Director of the Infrastructure Institute at the School of Cities, University of Toronto. Matti's work focuses on delivering large-scale infrastructure projects, evidence-based infrastructure investment decisions, and the effective integration of infrastructure into the fabric of cities. Matti reviewed the TTC's budgets and investment plans, including a review of major unfunded programs.

Dr. Amer Shalaby is a professor in the Department of Civil & Mineral Engineering at the University of Toronto. His research focuses on crowds and congestion, with particular emphasis on disruption management to help transportation authorities respond more effectively to unexpected impediments or crises. Amer researched the benefits and costs of transit service frequency and reliability.

Dr. Ignacio Tiznado Aitken is a postdoctoral fellow at Mobility Network, University of Scarborough and a member of Suburban Mobilities. His research interests encompass a wide range of topics associated with sustainable transport and transport justice in urban and suburban areas. Ignacio researched the social and community benefits.

Dr. David A. Wolfe is a professor in the Department of Political Science, University of Toronto Mississauga, and is the Co-Director of the Innovation Policy Lab at the Munk School of Global Affairs & Public Policy at the University of Toronto. His research interests include the role of local and regional clusters in economic development, with special reference to Canada and Ontario. David provided analysis on the contribution of transit to regional and economic development.

Chapter 1

Introduction

Prof. Eric J. Miller

Professor, Department of Civil and Mineral Engineering
Director, Mobility Network at the University of Toronto School of Cities

Dr. Judy Farvolden

Managing Director, Mobility Network at the University of Toronto School of Cities

As the TTC and the City of Toronto are debating TTC operating and capital budgets within a context of significant fiscal challenges, it is critical to understand the fundamental role that the TTC plays in the economic and social life of the residents of Toronto. In particular, it is essential for decision-makers to clearly understand that TTC operating and capital budgets represent <u>investments</u> in Toronto's current and future health and well-being. Public transit is a "must have", not a "nice to have" if Toronto is to continue to grow and prosper.

Cities exist to bring people and their enterprises together to create economic and social interactions and, thereby, wealth and well-being. They are vast "social networks" that create both economies of scale (bigger cities are more efficient than smaller cities) and agglomeration benefits (bigger cities are more productive per person than smaller cities) (Bettencourt, 2013). Agglomeration effects are particularly important since this is how increases in wealth and social well-being are generated. Investment in public transit accelerates the "positive feedback loops" within the economy in which the improved accessibility provided by the transit system generates increased economic activity, which, in turn, generates increased demand for transit, which justifies further improvement in these services, which then generate further economic development, and so on (Dachis and Godin, 2021). This is a "virtuous cycle" in which investment in transit begets economic growth, which stimulates (and enables financing of) further infrastructure (and other) investments. But feedback loops can run in both directions, which means that disinvestment in critical infrastructure, such as public transit, will lead to a "vicious cycle" of economic decline, resulting in further decline in infrastructure investments, such has been seen in a number of US cities, for example, which have failed to maintain their infrastructure and economic bases.

Public transit is integral to the effective functioning of these economic and social interactions. It enables the economy to operate by connecting workers to jobs, students to schools, shoppers to stores, etc. Moreover, the TTC is a large economic enterprise, whose operations and investments have significant impacts on the regional and national economies, over and above the direct and indirect travel-related impacts discussed within this report. Investing in the TTC not only generates travel-related benefits, but broader economic benefits as well.

Neither active travel modes (walking and biking) nor the automobile are sufficient to support the vast number of daily interactions (trips) needed to keep a city the size of Toronto functioning. Transit is an intrinsic, critical part of the "wiring" or "machinery" of the city. Just as an assembly line in a factory must be maintained and kept in working order for the factory to remain in operation, so too must a city's transit system be kept in a state of good repair if the city is to function. And just as the factory's technology needs to be improved and upgraded over time if the factory is to grow and increase its productivity, so too must we invest in improved and expanded transit services if the city is to grow and increase its wealth and well-being. Thus, investment in transit operations has direct economic benefits in terms of enabling job growth[6] and, more generally, increased economic productivity and benefits.[7] Conversely, disinvestment in transit by failing to maintain a state of good repair and by allowing service quality to degrade will result in reductions in economic productivity and will hobble Toronto's ability to grow. Indeed, failure to invest in maintaining and improving public transit is a recipe for Toronto's decline as a place in which to invest and to live.

In particular, it is important to recognize that the City of Toronto and the Toronto-centred urbanized region of the Greater Toronto-Hamilton Area (GTHA) and Greater Golden Horseshoe (GGH) are engaged in a global competition for population, jobs and economic development. A comprehensive, effective, efficient and attractive local and regional public transit system is an essential prerequisite to succeed in this competition. Toronto's peer competitor global cities in North America, Europe, Asia and Australia all have extensive, well-funded transit systems that are typically well subsidized and being continuously expanded. TTC operations are among the least subsidized, and our capital investment in both system state of good repair and essential system expansions has been minor, compared to most competitors. Toronto has "gotten by" with this underinvestment over the past several decades through a combination of very efficient operations, a well-designed integrated network of buses, streetcars and subways, and wise investments in the system in the 1950's, 60's and early '70's. But investments since the

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[6] The Canadian Centre for Economic Analysis estimates that every $1 million in infrastructure investment in Ontario directly generates 9 job-years of additional economic activity before accounting for follow-on spin-off effects (CANCEA, 2020). See also ITF-C40 for the effect of public transit investment on job growth.

[7] The C.D. Howe Institute, for example estimated an economic loss to the Toronto region due to mid-pandemic reduced TTC ridership of $1.2-1.4 billion (Dachis and Godin, 2021).

mid-70's have not kept up with city and regional growth, and Toronto cannot hope to continue to be globally competitive unless we acknowledge this long-standing shortfall and act to rectify it (Toronto Region Board of Trade, 2021).

These challenges have been exacerbated by the COVID-19 pandemic of the past 2.5 years, which resulted in massive declines in ridership (and, hence, revenues) and unprecedented operational challenges for the TTC. While ridership is returning and can be expected to eventually return to pre-pandemic levels (Miller, 2022), the short- and medium-term fiscal challenges for the TTC remain. While in a time of fiscal challenges there is great temptation to "cut costs", in the case of public transit this would be an extremely "penny-wise and pound-foolish" strategy that could easily result in long-term (and perhaps even irreversible) decline in Toronto's national and global economic competitiveness and quality of life.

Public transit competes directly with the private automobile for riders. Having said that transit is essential to the city's economic functioning, it can only play this role if it provides a cost-effective, attractive alternative to the car. Transit lines must run at high frequencies (especially in peak periods) to minimize waiting and transfer times. Transit vehicles must run at reasonable speeds and high reliability, with priority to minimize delays at signalized intersections and due to on-road congestion. And a spatially comprehensive, hierarchical transit network must exist that provides approximately door-to-door journeys and that cost-effectively matches line capacity (technology and performance) to demand. None of this is possible without adequate funding of day-to-day operations and on-going investment in the state of good repair of the system that ensures the required reliable, high-quality service.[8]

This discussion paper has been assembled by a group of leading researchers within the University of Toronto Mobility Network[9] to demonstrate the assertion above concerning the primary role of public transit as an irreplaceable, essential element of Toronto's physical, economic and social infrastructure. Numerous recent reports and studies have addressed this question from various perspectives, including CANCEA (2020), CUTA (2019), C.D. Howe (Dachis and Godin (2021)) and ITF-C40 (2021), a joint International Transit Federation and C40 Cities report. This paper complements these previous studies by drawing together our collective understanding, based on decades of research, of the fundamental role of public transit in cities in general and Toronto in particular. The remainder of the paper does this in eight parts, discussing in turn:

- Chapter 1: the fundamental role that investments in the TTC play in the lives and future health and well-being of the residents of Toronto and beyond.
- Chapter 2: the investment challenges and opportunities as incorporated within the current TTC operating and capital budgets.

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[8] https://www.toronto.ca/services-payments/streets-parking-transportation/transit-in-toronto/transit-funding/

[9] https://www.mobilitynetwork.utoronto.ca/

- Chapter 3: understanding the significant impacts of transit investments on the regional and national economies.
- Chapter 4: understanding Toronto’s ongoing evolution, and the role that transit plays, within the regional, national and global economies.
- Chapter 5: the TTC’s current position within the Toronto travel market and the large and irreplaceable role it plays in moving people and making Toronto “work”.
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Chapter 2
TTC Current Investments

Prof. Matti Siemiatycki
Professor, Department of Geography and Planning
Director, Infrastructure Institute at the University of Toronto

2.1 Introduction

In December 2021, the TTC released its 2022 Operating Budget and 2022-2031 Capital Budget & Plan. These include three components: the 2022 operating budget; the 2022-2031 Capital Budget & Plan, and the Real Estate Plan. Through the implementation of these plans, the TTC aims to deliver customer satisfaction, financial sustainability, be an inclusive and accessible transit service provider, and ensure system resiliency through innovation.

Over the past few years, the TTC has refined its budgeting process to provide greater clarity about the capital needs to maintain a state of good repair and service expansion and support growth, and to distinguish between projects that are funded and unfunded within the budget. In 2019, the TTC began producing a rolling 15-year Capital Investment Plan (CIP), which is updated annually. The 2022 budget cycle adds further refinements. First, it explicitly highlights the interdependencies in the investments that are being made. Second, for the first time the TTC has produced a real estate plan to identify the property of the organization for operational purposes, and the ways that leveraging TTC land holdings can contribute to city building initiatives.

The 2022 budget documents provide an overview of the TTC's strategic and financial direction with respect to service provision and capital investments over the coming decade. They reveal a transit system that is grappling to overcome longstanding operational and financial challenges that were exacerbated by the pandemic and making plans in the context of uncertainty about the future of transit ridership demand. The operating and capital plans set the path for COVID recovery, putting the TTC on a firmer financial footing, and addressing longstanding state of good repair backlogs while plotting a course for long-term service and ridership growth. These are plans are discussed in turn in the following two sections.

The 2022 budget also recognizes that to get the most from transit investments, they must advance on four fronts in a coordinated way. If there is investment in one category, but others fall behind, the entire system is weakened. Specifically, these four fronts are:

- Fleet: Subway trains, buses, Wheel-Trans vehicles and streetcars needed to move customers smoothly.
- Operations/Facilities: Garages, shops, carhouses and yards for fleet maintenance, storage. and other operational needs.
- System/Network: Track, signals, power and stations required for fleet to travel safely, quickly, and reliably.
- Real Estate: Property and buildings required for both systems/network and operations/facilities”.[10]

Section 2.4 explicitly addresses the issue of the economic benefits of the proposed TTC Capital Investment Plan through a macroeconomic modelling exercise to quantify the stimulus that this investment s likely to have on the national, provincial and regional economies.

2.2 Operating Budget: Pandemic Recovery and Beyond

The onset of the COVID-19 pandemic had a devastating impact on transit systems around the world. The TTC was no different. Pre-pandemic, the TTC was already facing ridership growth that had plateaued, rising fares, service reliability challenges on surface routes in particular, and tight financial conditions that have limited service expansion. At the height of the pandemic, TTC ridership was down by as much as 90%. The TTC costs $2.2 billion per year to operate in 2022 and has historically had the highest operating cost recovery rate from the fare box in North America, so the overnight drop in ridership had an especially devastating impact on the financial health of the system. The TTC was at very real risk of entering a period of systemic decline, wherein loss of ridership leads to accompanying lost revenue, which then would necessitate service cuts, which makes the service less attractive and leads to further lost ridership and revenues.

In Toronto, subsidizing the operating costs of the TTC not covered by fare revenue is a City of Toronto responsibility, despite having the fewest available revenue tools of all orders of government. This is a uniquely Ontario-based problem, since higher levels of government generally help subsidize transit operations throughout the rest of North America and, indeed, the world. Pre-pandemic the TTC received City investment from tax revenues totalling around $675 million per year to augment farebox revenue, a significant amount in a perennially

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[10] https://ttc-cdn.azureedge.net/-/media/Project/TTC/DevProto/Documents/Home/Public-Meetings/Board/2021/Dec-20/3_Presentation_CIP_REIP_Capital_Budget_and_Plan.pdf?rev=a13b6a45f2754c53ad850eb5041ab3fa&hash=75EFBD10A133A1B020B3716B60A95F09

stretched City budget.[11] In 2020-2022, in the face of dramatic ridership revenue shortfalls due to the pandemic, the Federal and Provincial governments broke with their contemporary practice of not directly funding transit operating costs, and provided the TTC with $1.2 billion in emergency operating funding on top of an increase in the City's annual operating contribution. This staved off the need for devastating cuts and enabled the TTC to freeze fares and continue providing its critical lifeline service through the pandemic.

Indeed, ridership figures highlight the importance of transit to the city. Throughout the height of the pandemic, bus ridership remained higher than on the subway and streetcars, often in the inner suburbs serving frontline workers and transit dependent riders who are disproportionately lower income, racialized and newcomers to Canada. Bus crowding was an issue on some routes through the pandemic.

In 2022, as Toronto re-opens from pandemic closures and more activities and events are being held in person, transit ridership is beginning to recover. The TTC Board committed to providing 100% of service, with 50% ridership demand. The TTC's wider service plan for 2023-2024 focuses particularly on enhancing the surface transit network, which has struggled with reliability issues, by adding more buses and streetcars to key routes and at off peak hours; piloting new shuttle and community services, especially in priority neighbourhoods; improving surface transit shelters and their adjacent areas; and expanding service integration with surrounding transit services. Studying dedicated bus lanes on key arterial roads in the inner suburbs is in the plan, but funding is not committed for rapid implementation.[12] The operational plan represents an incremental improvement to the provision of transit service in Toronto.

Investing in the ramping back up and improvement of transit services in Toronto is important economic and social policy to support a safe, sustainable, and equitable restart for the city, but has significant financial cost implications for the TTC. The TTC is paying to provide full service as ridership revenues gradually recover. In the third quarter of 2022, transit ridership was at 65% of pre-pandemic levels, with a $1.4 billion revenue gap between fare revenues and total costs being made up by a combination of $851.4 million from the City and $561 million from the province and federal governments. In the years ahead, the cost pressures on the TTC's operating budget will only grow: the opening of new major capital services like the Eglinton Crosstown and Finch LRTs add new operating costs, and fuel prices have increased, among other inflationary cost factors.

Now as TTC ridership is slowly recovering and projected to take 2-3 years to return to pre-pandemic levels, the Federal government (and potentially the Province) are signalling that they will be ending their COVID emergency operating grants to urban transit systems. At the same

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[11] https://www.toronto.ca/legdocs/mmis/2019/cc/bgrd/backgroundfile-130605.pdf

[12] https://ttc-cdn.azureedge.net/-/media/Project/TTC/DevProto/Documents/Home/About-the-TTC/5_year_plan_10_year_outlook/TTC_5_year_SP_web_accessible_Action_Plan_.pdf?rev=c65098546998497dbeb07ff54d781f81&hash=997B07F619CFFA102B6A783BC86B165E

time, the City of Toronto is struggling with its own major operating budget deficit without the revenue sources to fill the gap. Given the high level of subsidy the TTC is relying on to provide service until ridership recovers, government retrenchment from providing operating support for transit would create a financial crisis at the TTC that would necessitate significant cuts across the system.

2.3 Capital Plans: State of Good Repair

One of the paradoxes of the current moment is that at the same time as the TTC and other transit systems across the country are facing uncertainty around transit operating grants from government that are critical to maintain service levels, there is more public money than ever being spent on transit capital investments. In Toronto, the flashy, high profile and expensive capital expansion projects being undertaken during the current period are predominantly being led by the provincial agency Metrolinx. The Ontario Line, Scarborough Subway extension, Eglinton West LRT extension and Yonge Subway extension, have a total capital value of $28 billion, and represent the largest burst of rapid transit expansion in Toronto's history. While the TTC has not contributed significantly to the capital costs of these projects from its own capital budget, it will have a role in operating some of the new services and will incur new operating costs when they open, potentially further exacerbating operating financial shortfalls.

By contrast, the TTC has the less glamorous but no less important role of maintaining and expanding the capital assets of the existing transit network. In the 2022 Capital Investment Plan, the TTC has identified $23.3 billion in capital spending need over the next 10 years, of which only $12 billion, or just over half, is funded. Of the funded projects, 57% of spending is on state-of-good-repair and legislated health and safety improvements, while 43% of the funding is for investments to support expansion. Like all transit agencies, the TTC must grapple with making long-term capital investment plans during a period of significant uncertainty about whether transit ridership flows and patterns will return in the same way as pre-pandemic.

The bulk of the funding is earmarked towards overhauling and expanding the TTC's bus and streetcar vehicle fleet with low floor, zero emission vehicles and implementing Automated Train Control and other upgrades on Lines 1 and 2 of the subway system to improve operations and increase capacity. These investments support safe and reliable transit operations, the core foundation for system operation and expansion.

Funding is additionally allocated to improve subway station accessibility to meet AODA requirements. In some cases, capital investments such as the purchase of new more energy efficient vehicles contribute to lower operating costs. Only a tiny fraction of all capital funding ($71 million or 0.6%) is being allocated for surface transit infrastructure improvements such as transit loops and on street transit priority investments such as dedicated bus lanes that improve surface transit reliability.

Five years after the Toronto-York-Spadina Subway Extension opened, the TTC is also budgeting an additional $64 million dollars in project close out costs. This highlights that the capital costs of major infrastructure projects can stretch well beyond the ribbon cutting and need to be sufficiently budgeted for. With a major, multi-year capital investment program underway, the TTC is planning to significantly increase its internal project management capacity.

The TTC’s real estate plan picks up on the emerging trend in the sector of seeing transit investments as a means of moving people, as a fundamental catalyst for the development of complete communities, and as a way to generate financial value from land value uplift. The TTC’s plan focuses on maximizing the efficiency of the TTC’s current real estate portfolio by optimizing property usage, integrating TTC services into third-party developments, and supporting redevelopment opportunities on surplus lands. It is an initial step in envisioning the TTC as a transit service provider and a contributor to broader city building goals, a step that leading transit agencies have taken around the world.

The Capital Improvement plan is grouped into major programs to illustrate their critical interdependencies. Emphasis is placed on coordination and integration of investments – efficiency benefits and ensuring that programs fit together to maximize the financial, environmental and social benefits. For instance, the purchase of a fleet of electric buses requires the funding and installation of charging stations at vehicle depots, which requires upgrades to power systems. Similarly, expansion of the streetcar and subway train fleet require expanded maintenance yards. Careful planning is necessary to ensure that funding one portion of the Capital Investment Plan program while leaving others unfunded does not undermine the outcome from the investments.

The City of Toronto is the largest funder of the TTC’s 10-year Capital Investment Plan with a contribution of $7.8 billion or 65% of the total expenditure, primarily through its City Building Fund. Of the remaining 35% of the Capital Investment Plan budget ($4.3 billion), the province is contributing 13% of the funds and the federal government 22% of the funds. The federal government is currently consulting on an annual $3 billion permanent transit fund which is likely to expand federal capital contributions for the TTC and other transit agencies starting in 2026.

Taken as a whole, the 10-year investment plan as drafted represents a blueprint to fall further behind on the capital needs of the TTC. Importantly, after investing $12 billion in capital projects over 10 years, the amount of money allocated annually to address state of good repair on the system declines. However, the total amount of unfunded capital projects balloons from $11.257 billion in first years 1-10 of the plan to $22.541 billion after 15 years of implementing the current plan. Unfunded projects include the Waterfront East LRT (though money is set aside for further planning), subway platform screen doors, service planning initiatives such as dedicated bus lanes, and bus, subway, and streetcar overhauls to extend the useful life of these vehicles.

As governments at all levels face increased budget pressures and reduced fiscal capacity as a result of the pandemic, coupled with rising interest rates and inflation, the TTC is vulnerable to potential capital budget cuts in the years ahead. The disruption of stable, predictable long-term government funding for capital investments would pose a risk to the reliability of transit service in Toronto and undermine the potential for the TTC to deliver social, environmental and economic benefits for the city.

Chapter 3
The Macroeconomic Impacts of TTC Investment Scenarios

Prof. Richard J. DiFrancesco
Chair and Associate Professor, Department of Geography and Planning

3.1 Introduction

This chapter describes how the TTC's investment plans for the next 15 years impact the broader economy. The economic system is described as a Multi-regional Input-Output (MRIO) Model to generate a first cut at illustrating just how various TTC investment scenarios could impact the provincial and national economies of Canada, given the assumptions inherent in the model. The results illustrate that the TTC investment scenarios for the coming 15-year period stand to have very significant economic impacts in Toronto, Ontario and the rest of Canada.

3.2 TTC Investment Scenarios

In December 2022, the TTC provided information on 13 scenarios reflecting various strategic priorities and degrees to which planned investments are to be funded over the coming 15-year period. These scenarios were used to drive an MRIO model of the Canadian economy, defined as 13 provinces and territories interacting in trade across 186 industrial sectors.

Table 3.1 provides information on these investment scenarios. The scenarios represent the amount of investment, by broad categories, that is planned for the coming 15-year period. They differ significantly from one to the other reflecting different levels of funding commitment.

In addition to providing the total amount of investment for each scenario shown in Table 3.1, the TTC provided detailed capital expenditure plans including the fine-grained details of the individual investments that comprise each scenario. This information was translated into industry-terms that were consistent with the MRIO model developed for this project (see Table 3.2).[13]

Table 3.1: TTC (15-year total) Investment Scenarios

Grouping	**SC #**	**Description**	**Total (in dollars)**
Total (FUNDED + UNFUNDED)	01	Total CIP	***37,489,117,662.00***
	02	Total - Transit Access	***1,254,123,815.25***
	03	Total - Safety Reliability	***17,050,567,409.75***
	04	Total - Environmental	***4,761,158,761.00***
	05	Total - Capacity Growth	***17,271,479,905.00***
FUNDED	06	Funded	***12,321,895,444.00***
	07	Funded - Transit Access	***784,166,455.25***
	08	Funded - Safety Reliability	***5,130,350,031.75***
	09	Funded - Environmental	***854,254,199.00***
	10	Funded - Capacity Growth	***5,699,129,012.00***
UNFUNDED PRIORITIES	11	Unfunded Priorities - Capacity	***3,894,950,752.00***
	12	Unfunded Priorities - Electrify	***2,647,298,319.00***
	13	Unfunded Priorities - SOGR	***1,364,196,529.00***

Table 3.2: Sampling of L97 Industries Used to Map TTC CIP to Provincial Input-Output Accounts

Expenditures in TTC CIP	**L97 Industries Targeted in the MRIO**
Subway/Track Rehabilitation Program	Transportation Engineering Construction
Subway/Substation Lighting Replacement	Electric Power Engineering Construction
Industrial Security Improvements TTC Properties	Investigation and Security Services
Subway Cars	Railroad Rolling Stock Manufacturing
Subway Asbestos Removal Program	Management, Scientific and Technical Consulting Services
LAN/WAN (including Wi-Fi throughout the TTC)	Data Processing, Hosting and Related Services

Even without a modelling exercise, one can clearly see that the scenarios laid out in Table 3.1 stand to have a significant impact locally, provincially, nationally and, indeed, internationally. The first scenario in Table 3.1 (SC1), which involves all aspects of the TTC Capital Improvement

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[13] The MRIO model was developed using the Symmetric Provincial Input-Output Tables for Canada for 2018 which is the most recent available at the time of writing. These tables express economic activity in each province and territory in terms of 186 industrial sectors and several hundred final demand categories.

Plan (CIP) being funded, amounts to nearly \$37.5 billion worth of investment over 15 years. The sheer magnitude of this scenario is apparent when one considers that in 2021, GDP for the Province of Ontario was nearly \$971 billion. In other words, the full TTC CIP amounts to nearly four percent (4%) of 2021 provincial GDP.

3.3 The Multi-Regional Input-Output Model

The Input-Output approach to measuring economic impacts is commonplace and often controversial. The approach is commonly used because it is relatively straightforward to implement and controversial because its use implies adherence to several challenging assumptions. To name a few, the use of the model involves accepting the assumption that there are no capacity constraints in the economy in question, and therefore, whatever demands are placed on industries will be satisfied and thereby create associated direct, indirect (and possibly induced) impacts. However, if an economy is operating at or near full capacity already, a significant demand shock could likely only be satisfied by imports (because domestic industries are at or near capacity) or by price inflation to rationalize demand and supply. Neither of these situations eventuate inside the model, rather the model assigns the output levels to individual industries that are required to meet any prescribed level of final demand. It is also important to keep in mind that another assumption is that the cost per unit of production across industries is invariant across the scale of output, which is also counter to established theory and can lead to either over- or under-estimates of true impacts, again depending on specific local conditions.

The MRIO model used in this analysis represents one method of operationalizing what has been called the Interregional Input-Output Model (IRIO). It is also referred to as the Chenery-Moses approach.[14] The MRIO model can be expressed as follows:

$$\Delta X = (I - CA)^{-1} C \Delta F$$

where:

X = a vector of industry outputs (in this case, consists of 186 industries by 13 regions);
C = a matrix of interregional trade coefficients (computed using available trade data);
A = a matrix of technical coefficients showing how industries buy and sell to and from each other.
F = a vector of Final Demand elements (e.g., Investment, Exports, Consumption)
Δ = delta operator meaning “change-in”.

The MRIO model as shown in the equation above was implemented using the Symmetric Provincial Input-Output Tables for 2018. This model takes the given TTC investment scenarios (as ΔF) and translates them into industry output levels (ΔX) across all industries (186) in all regions (13) as indicated by the technical coefficient and interregional trade coefficients

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[14] See Miller and Blair (2009). “Input-Output Analysis: Foundations and Extensions (2nd Edition).” Cambridge University Press, Cambridge.

matrices (A and C).[15] Each TTC investment scenario was translated into a specific ΔF vector (in terms of L97 industries in the System of National Accounts), and each was then “run through” the MRIO model to generate an associated ΔX vector showing how industries across all regions are impacted. The MRIO model was run 13 times to generate MRIO ΔX vectors for each case of the 13 investment scenarios described in Table 3.1.

3.4 Results

3.4.1 Gross Output Impacts

Table 3.3 sums impacts across 186 industries in each of the 13 regions of Canada to show the total gross output impacts (ΔX) that the MRIO model computes for each of the 13 TTC investment scenarios shown in Table 3.1.

Table 3.3 shows tremendous variation in terms of ΔX impacts across all scenarios ranging from a total impact of $90 billion over 15 years and across 13 regions in SC1 (the fully funded TTC CIP) to just over $2.6 billion for scenarios SC2 and SC9.

3.4.2 Value-Added (GDP) Impacts

The gross output impacts presented above are important in that they do measure the amount of activity taking place in each sector in a given location. However, it must be noted that these values are prone to double counting. For example, the selling price of steel rail for subway tracks includes the costs of all inputs borne in their production. Likewise, when each of these input providers sell their wares to a producer of steel rail, that price also includes all of the costs associated with their inputs, and so on. To remove this, gross output impacts can be expressed in terms of value-added which removes this double counting. Table 3.4 presents the value-added impacts associated with each of the TTC scenarios. Note the sectoral pattern revealed above for gross output holds for value added (or GPD).

3.4.3 Impacts on Jobs

Another often sought-after metric of economic performance/impact is jobs or employment. Table 3.5 expresses the impact of each of the TTC investment scenarios shown in Table 3.1 in terms of jobs created across all regions for the 15-year period.[16] [17]

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[15] See https://www150.statcan.gc.ca/n1/en/catalogue/15-211-X

[16] These jobs impacts were computed by multiplying MRIO generated ΔX values by Statistics Canada’s Job Multipliers. These multipliers, for a given industry in a given province, show jobs created per million dollars of gross output. (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610011301&pickMembers%5B0%5D=2.3&pickMembers%5B1%5D=3.14&pickMembers%5B2%5D=5.2&cubeTimeFrame.startYear=2014&cubeTimeFrame.endYear=2018&referencePeriods=20140101%2C20180101)

[17] The jobs multiplier refers to total jobs including employee jobs, self-employed jobs and persons working in a family business without pay. These are NOT FTEs.

Table 3.3: Total Gross Output Impacts by Scenario

INV	***37,489,117,662.00***	***$ 1,254,123,815.25***	***$ 17,050,567,409.75***	***$ 4,761,158,761.00***	***$ 17,271,479,905.00***	***$ 12,321,895,444.00***	***$ 784,166,455.25***	***$ 5,130,350,031.75***	***$ 854,254,199.00***	***$ 5,699,129,012.00***	***$ 3,894,950,752.00***	***$ 2,647,298,319.00***	***$ 1,364,196,529.00***
	SC1	**SC2**	**SC3**	**SC4**	**SC5**	**SC6**	**SC7**	**SC8**	**SC9**	**SC10**	**SC11**	**SC12**	**SC13**
NL	$ 196,775,179.19	$ 5,627,578.13	$ 73,477,162.76	$ 17,403,206.14	$ 109,995,176.34	$ 68,507,420.76	$ 2,392,160.52	$ 22,463,292.41	$ 2,471,817.89	$ 41,702,037.35	$ 23,681,922.82	$ 9,767,428.51	$ 4,231,989.11
PE	$ 19,746,255.91	$ 584,902.21	$ 9,664,922.63	$ 2,758,966.84	$ 8,464,182.52	$ 6,465,214.50	$ 351,577.53	$ 2,953,867.56	$ 484,750.46	$ 2,819,351.20	$ 1,995,469.79	$ 1,437,351.41	$ 758,848.15
NS	$ 168,858,245.32	$ 5,108,197.87	$ 82,856,922.50	$ 27,098,761.00	$ 72,013,260.85	$ 55,257,474.72	$ 3,086,669.45	$ 24,731,277.49	$ 4,646,717.73	$ 25,329,853.82	$ 16,665,115.28	$ 13,651,047.60	$ 6,555,477.19
NB	$ 206,721,504.74	$ 6,548,342.16	$ 101,409,352.66	$ 32,494,757.53	$ 85,776,920.68	$ 68,553,609.49	$ 4,104,967.28	$ 30,430,157.53	$ 4,842,315.54	$ 30,547,195.45	$ 22,964,790.30	$ 15,267,251.75	$ 8,586,876.44
QC	$ 4,509,818,942.24	$ 120,496,836.88	$ 2,315,656,678.27	$ 766,232,660.41	$ 1,797,877,211.98	$ 1,466,974,765.66	$ 72,031,085.38	$ 654,946,601.01	$ 112,723,785.25	$ 630,702,267.80	$ 656,454,759.11	$ 348,786,720.73	$ 261,548,339.63
ON	$ 80,346,028,294.16	$ 2,417,931,634.71	$ 39,541,989,446.70	$ 13,792,838,530.22	$ 34,437,620,610.34	$ 26,112,432,427.53	$ 1,451,827,636.76	$ 11,397,405,102.58	$ 2,408,533,613.86	$ 12,348,649,119.15	$ 8,730,034,795.01	$ 7,124,548,990.59	$ 3,490,442,894.43
MB	$ 682,661,537.13	$ 16,164,224.21	$ 344,392,923.70	$ 139,531,035.33	$ 257,067,265.55	$ 214,348,108.89	$ 9,330,277.50	$ 98,085,911.80	$ 16,863,537.71	$ 88,813,450.02	$ 94,880,442.14	$ 51,355,985.05	$ 38,490,975.00
SK	$ 412,904,648.03	$ 11,441,967.68	$ 184,254,194.45	$ 54,904,152.84	$ 199,503,936.80	$ 139,425,709.01	$ 5,648,526.24	$ 54,583,209.54	$ 8,792,747.51	$ 75,100,557.14	$ 48,546,675.88	$ 28,601,117.29	$ 14,084,617.87
AB	$ 2,280,999,845.31	$ 66,085,806.21	$ 969,738,991.94	$ 272,210,830.24	$ 1,157,797,386.18	$ 776,730,268.24	$ 32,278,858.03	$ 289,579,828.16	$ 45,525,276.39	$ 434,454,094.71	$ 261,370,380.82	$ 148,946,432.67	$ 68,500,917.91
BC	$ 1,161,068,487.93	$ 30,004,134.36	$ 574,101,538.24	$ 173,186,989.78	$ 484,621,799.00	$ 377,377,452.45	$ 17,513,143.30	$ 169,667,222.61	$ 26,669,536.26	$ 158,791,799.16	$ 153,298,671.54	$ 80,122,387.09	$ 60,275,241.83
YT	$ 7,798,860.27	$ 190,915.29	$ 3,443,121.16	$ 2,020,538.55	$ 2,888,348.21	$ 2,303,638.26	$ 116,225.43	$ 996,830.92	$ 184,093.52	$ 937,250.14	$ 843,915.87	$ 559,896.33	$ 345,723.20
NT	$ 11,040,560.75	$ 308,168.97	$ 4,576,175.65	$ 1,272,101.31	$ 5,515,906.63	$ 3,508,638.72	$ 170,537.54	$ 1,394,401.48	$ 224,067.62	$ 1,643,362.79	$ 1,085,789.11	$ 649,891.46	$ 349,751.36
NU	$ 17,332,767.00	$ 356,832.79	$ 7,739,225.44	$ 6,049,849.96	$ 5,130,111.42	$ 4,785,696.57	$ 226,407.17	$ 2,181,957.56	$ 420,543.21	$ 1,717,731.35	$ 2,003,133.13	$ 1,333,697.34	$ 895,080.73
	$ 90,021,755,127.97	**$ 2,680,849,541.48**	**$ 44,213,300,656.11**	**$ 15,288,002,380.16**	**$ 38,624,272,116.48**	**$ 29,296,670,424.79**	**$ 1,599,078,072.13**	**$ 12,749,419,660.65**	**$ 2,632,382,802.94**	**$ 13,841,208,070.08**	**$ 10,013,825,860.79**	**$ 7,825,028,197.84**	**$ 3,955,066,732.85**

Table 3.4: Total Value-Added Impacts by Scenario

INV	***37,489,117,662.00***	***$ 1,254,123,815.25***	***$ 17,050,567,409.75***	***$ 4,761,158,761.00***	***$ 17,271,479,905.00***	***$ 12,321,895,444.00***	***$ 784,166,455.25***	***$ 5,130,350,031.75***	***$ 854,254,199.00***	***$ 5,699,129,012.00***	***$ 3,894,950,752.00***	***$ 2,647,298,319.00***	***$ 1,364,196,529.00***
	SC1	**SC2**	**SC3**	**SC4**	**SC5**	**SC6**	**SC7**	**SC8**	**SC9**	**SC10**	**SC11**	**SC12**	**SC13**
NL	$ 91,618,082.24	$ 2,580,175.32	$ 34,853,047.29	$ 9,145,237.30	$ 49,952,887.84	$ 31,589,580.39	$ 1,118,642.67	$ 10,621,587.21	$ 1,237,873.11	$ 18,825,784.75	$ 10,974,086.65	$ 4,757,593.09	$ 2,139,868.22
PE	$ 9,375,892.84	$ 277,608.81	$ 4,546,139.55	$ 1,290,750.97	$ 4,069,266.67	$ 3,068,957.44	$ 165,874.19	$ 1,385,348.21	$ 229,249.78	$ 1,353,035.96	$ 951,439.29	$ 679,136.91	$ 358,485.21
NS	$ 80,089,691.69	$ 2,428,306.36	$ 38,308,840.94	$ 11,989,017.20	$ 35,208,917.10	$ 26,250,696.32	$ 1,449,527.56	$ 11,500,810.60	$ 2,088,372.96	$ 12,165,839.37	$ 7,929,977.76	$ 6,189,455.27	$ 2,990,051.97
NB	$ 83,138,676.40	$ 2,526,231.58	$ 40,346,960.00	$ 12,799,886.81	$ 35,107,252.61	$ 27,449,715.21	$ 1,537,967.22	$ 12,081,520.24	$ 1,937,099.46	$ 12,355,337.15	$ 9,317,252.35	$ 6,049,663.19	$ 3,445,373.44
QC	$ 2,006,894,846.85	$ 54,056,521.69	$ 1,010,609,342.62	$ 339,073,992.54	$ 817,920,418.29	$ 652,831,370.98	$ 31,839,097.14	$ 287,265,540.70	$ 50,127,765.95	$ 288,204,536.39	$ 280,565,341.27	$ 154,857,301.71	$ 109,899,567.79
ON	$ 33,429,485,283.79	$ 1,100,016,398.93	$ 15,346,739,786.72	$ 4,563,183,170.05	$ 15,345,586,631.27	$ 10,905,897,189.38	$ 690,591,958.13	$ 4,574,816,290.52	$ 818,010,513.05	$ 5,116,411,982.11	$ 3,327,679,660.19	$ 2,486,201,437.11	$ 1,201,498,109.67
MB	$ 343,807,717.44	$ 8,284,483.02	$ 169,963,471.92	$ 69,576,148.18	$ 132,857,181.71	$ 108,332,585.10	$ 4,703,353.22	$ 48,614,122.35	$ 8,383,239.85	$ 46,490,884.47	$ 46,309,270.12	$ 25,707,297.73	$ 18,307,077.89
SK	$ 217,419,847.55	$ 5,984,197.57	$ 96,695,784.87	$ 29,294,059.82	$ 105,349,825.35	$ 73,272,191.16	$ 2,920,994.40	$ 28,512,784.98	$ 4,678,134.08	$ 39,766,661.52	$ 25,633,198.49	$ 15,139,702.46	$ 7,416,839.45
AB	$ 1,175,219,450.54	$ 33,830,883.67	$ 497,347,338.33	$ 138,096,391.56	$ 599,780,956.64	$ 400,307,806.43	$ 16,361,935.30	$ 148,551,867.55	$ 23,238,413.08	$ 224,714,335.04	$ 135,122,404.39	$ 76,218,790.11	$ 35,105,136.40
BC	$ 583,692,095.47	$ 15,433,993.02	$ 282,327,339.39	$ 85,028,215.51	$ 249,932,939.65	$ 190,696,166.65	$ 8,893,745.81	$ 84,353,029.16	$ 13,230,594.46	$ 82,967,950.86	$ 73,021,606.33	$ 39,923,287.07	$ 27,874,530.35
YT	$ 4,511,856.33	$ 110,634.60	$ 2,000,293.09	$ 1,176,907.28	$ 1,659,896.74	$ 1,336,185.32	$ 67,458.47	$ 578,800.58	$ 107,020.18	$ 543,395.83	$ 489,077.43	$ 326,078.27	$ 201,193.11
NT	$ 5,131,117.86	$ 144,248.92	$ 2,148,885.81	$ 596,731.26	$ 2,542,691.79	$ 1,643,191.51	$ 80,230.36	$ 654,791.37	$ 105,117.61	$ 766,290.37	$ 505,198.82	$ 305,537.15	$ 165,203.14
NU	$ 9,099,397.17	$ 190,643.69	$ 4,065,554.00	$ 3,120,737.41	$ 2,734,114.31	$ 2,531,933.07	$ 120,660.01	$ 1,149,118.81	$ 219,962.10	$ 919,868.15	$ 1,048,165.45	$ 698,138.05	$ 465,368.93
	$ 38,039,483,956.16	**$ 1,225,864,327.18**	**$ 17,529,952,784.54**	**$ 5,264,371,245.89**	**$ 17,382,702,979.96**	**$ 12,425,207,568.97**	**$ 759,851,444.47**	**$ 5,210,085,612.26**	**$ 923,593,355.67**	**$ 5,845,485,901.98**	**$ 3,919,546,678.55**	**$ 2,817,053,418.12**	**$ 1,409,866,805.55**

Table 3.5: Jobs Impacts by Scenario

INV	***37,489,117,662.00***	***$ 1,254,123,815.25***	***$ 17,050,567,409.75***	***$ 4,761,158,761.00***	***$ 17,271,479,905.00***	***$ 12,321,895,444.00***	***$ 784,166,455.25***	***$ 5,130,350,031.75***	***$ 854,254,199.00***	***$ 5,699,129,012.00***	***$ 3,894,950,752.00***	***$ 2,647,298,319.00***	***$ 1,364,196,529.00***
	SC1	**SC2**	**SC3**	**SC4**	**SC5**	**SC6**	**SC7**	**SC8**	**SC9**	**SC10**	**SC11**	**SC12**	**SC13**
NL	719.05	21.07	289.26	66.48	380.94	247.41	10.16	89.64	10.76	138.81	80.69	39.06	17.56
PE	189.50	5.57	91.82	26.02	82.22	61.56	3.35	28.07	4.66	26.78	18.68	13.66	7.12
NS	1,500.13	45.34	725.78	226.72	652.04	489.49	27.33	218.41	39.76	223.44	145.48	116.83	55.97
NB	1,300.19	39.88	630.48	193.56	553.21	428.88	24.40	189.87	30.33	192.35	141.06	94.01	52.09
QC	29,611.85	812.43	15,005.48	4,820.88	12,076.65	9,651.90	486.16	4,284.74	739.21	4,197.62	4,099.01	2,271.96	1,618.91
ON	490,768.82	15,903.91	229,005.04	66,311.85	223,036.23	160,735.18	9,908.20	68,619.80	11,958.67	75,116.81	48,599.65	36,612.15	17,436.12
MB	4,399.18	107.86	2,242.50	837.79	1,685.75	1,391.84	63.20	643.42	110.80	575.01	592.46	332.79	242.17
SK	2,283.08	63.80	1,046.89	311.20	1,074.99	766.12	32.91	310.70	51.66	398.68	261.04	163.74	81.09
AB	12,347.63	362.53	5,343.22	1,514.63	6,141.74	4,164.40	185.76	1,598.58	258.89	2,254.68	1,369.72	828.72	383.16
BC	8,341.14	222.33	4,055.52	1,185.41	3,569.78	2,696.42	130.74	1,203.90	193.00	1,144.58	1,035.96	573.81	404.42
YT	48.31	1.27	21.36	10.79	19.17	14.59	0.78	6.27	1.13	6.10	5.02	3.39	2.00
NT	59.36	1.67	24.81	6.97	29.40	18.75	0.94	7.56	1.22	8.72	5.79	3.54	1.88
NU	76.04	1.69	33.88	24.42	24.14	21.42	1.07	9.66	1.82	7.99	8.56	5.73	3.72
	551,644.27	**17,589.37**	**258,516.03**	**75,536.70**	**249,326.25**	**180,687.96**	**10,875.00**	**77,210.61**	**13,401.92**	**84,291.57**	**56,363.12**	**41,059.37**	**20,306.21**

It is important to remember that these jobs are forecast to manifest over a 15-year horizon (as are the ΔX and ΔVA impacts). It is also important to note that earlier comments about capacity constraints are apropos here. First, the temptation is for a reader to label these jobs as net new – that is, over and above those that would have been created in the provinces and territories in the absence of these scenarios. This could be the case, but it is more likely the case that these investment scenarios will actually draw labour away from other uses that would have employed them over this period, at least to some extent. The degree to which such impacts depict net-new employment has much to do with the nature of the labour market in a given region at a given time. As such, these scenarios should be treated as illustrative only.

3.4.4 Regional Distribution of Impacts

Not at all surprising in Tables 3.3, 3.4 and 3.5 is the fact that Ontario receives the largest share of the impacts associated with each investment scenario (89%) followed by Quebec (5%), Alberta (3%) and British Columbia (1%). (See Figure 3.1).

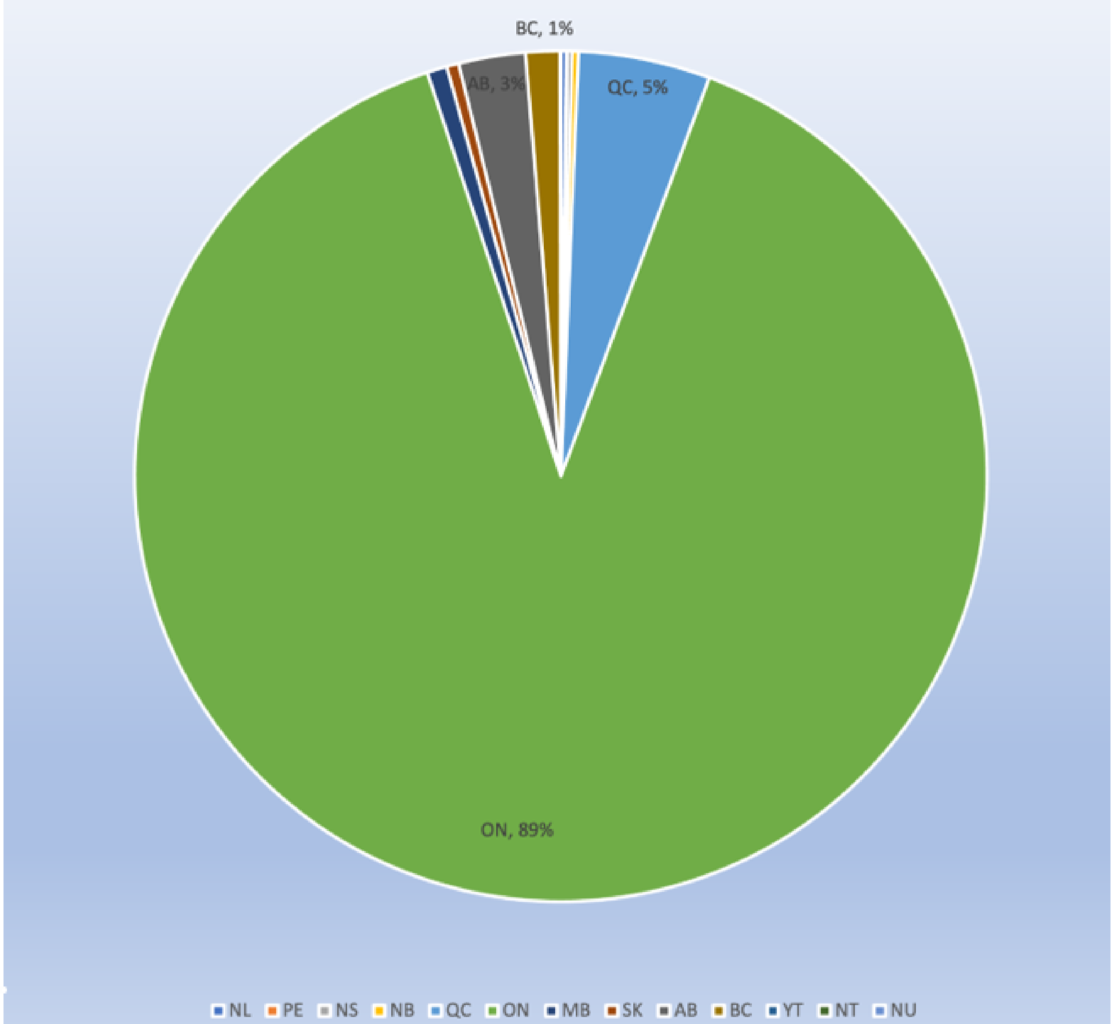

Figure 3.1: Regional Distribution of Economic Impact of TTC Investment Scenarios (SC1): 15-Year Horizon

3.4.5 Industrial Distribution of Impacts

Figure 3.2 presents an industrial breakdown of the impacts accruing to Ontario over the 15-year horizon of the first investment scenario (SC1). Figure 3.2 presents the MRIO model output aggregated from the native L97 level (186 industries) to the summary level (34 industries) for ease of exposition.

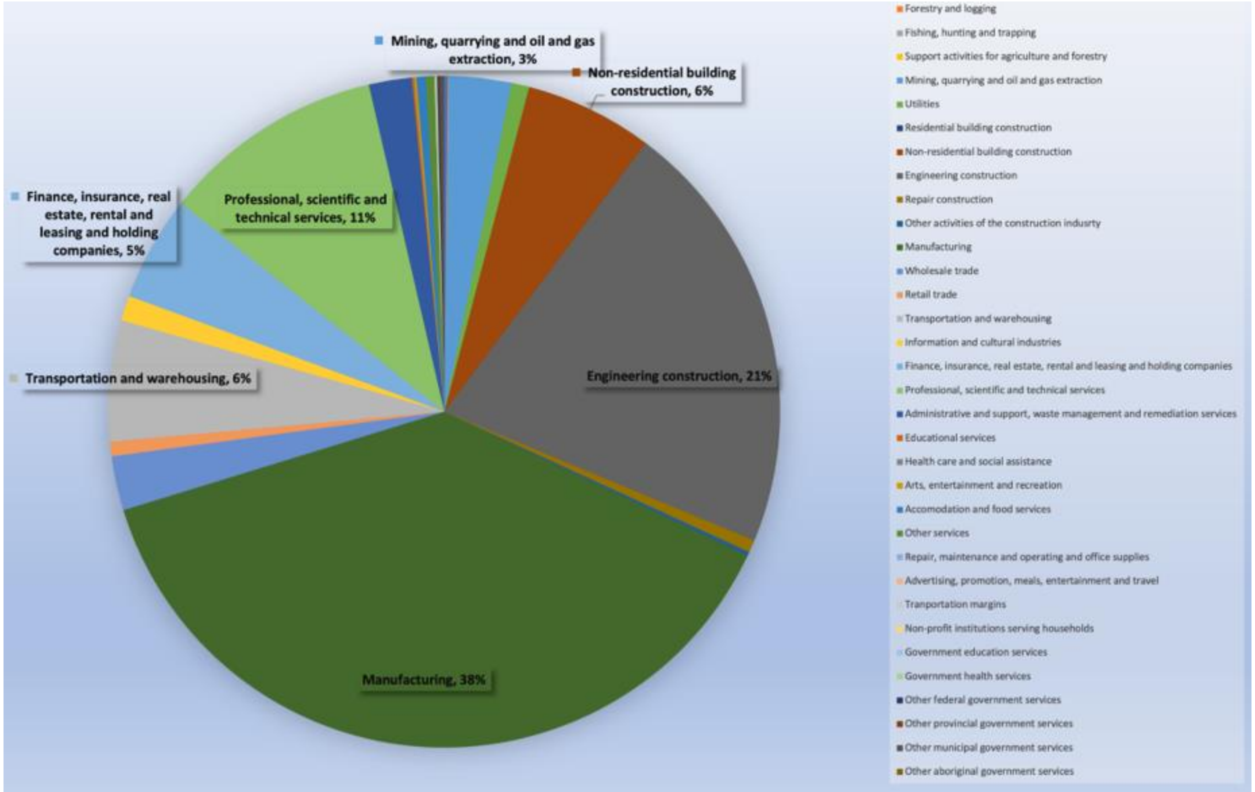

Figure 3.2: Industrial Distribution of Gross Output Impacts in Ontario: 15-Year Horizon

Figure 3.2 presents the industrial breakdown of the SC1 gross output impact in Ontario (over the 15-year period). Not at all surprising given the structure of the Ontario economy, the manufacturing sector accounts for the largest share of the total gross output impact in the province (38%), followed by engineering construction (21%), and professional, scientific and technical services (11%).

3.5 Concluding Remarks

The analysis reported above is meant to provide the TTC with a picture of how their investment plans stand to impact the broader provincial and national economies. As noted above, these impacts are to be considered to be an illustration of what could happen under some very strict assumptions vis-à-vis the working of these economies (i.e., the standard IO analysis assumptions). In the case of an economy which is currently operating near capacity (as reflected by overall price inflation), massive demand shocks such as those represented in the TTC investment scenarios discussed here, will undoubtedly impact prices of goods and labour and result in a shifting of production (to the most lucrative uses) and upward pressure on prices. The pictures present in the figures and tables above should be considered as illustrative only and not a forecast of future conditions.

What is clear however is that the capital expenditures of the TTC will have a profound economic impact in the Greater Golden Horseshoe (GGH) region (which accounts for the majority of Ontario’s high-value industrial activity) and Ontario generally. Also clear is the fact that the other regions of Canada will also be affected, but to a much to a much lesser degree.

It should also be kept in mind that production in the GGH and Ontario generally typically results in considerable international trade especially with US states. None of this activity is tracked in the model (i.e., international trade is exogenous to the MRIO model).

Chapter 4

The Toronto Region: An Expanding Regional Economy

Prof. David A. Wolfe

Professor, Department of Political Science, University of Toronto Mississauga
Co-Director of the Innovation Policy Lab at the Munk School of Global Affairs & Public Policy

4.1 Introduction

The Toronto Census Metropolitan Area (CMA) is the largest metropolitan region in the country. In 2019 it generated over 50% of Ontario's GDP and 20% of Canada's.[18] The city of Toronto lies at the centre of this region and is the leading urban centre in the country for many critical economic sectors. The coverage of the transit system and the ability to maintain the quality of its physical and operating infrastructure is critical to the economic vitality of the region. Research undertaken by the Mobility Network for the Economic Blueprint Institute at the Toronto Region Board of Trade has documented the daily commuting patterns between the city of Toronto and its surrounding municipalities. The research demonstrates that the bulk of the daily commuter flows are directed into the city of Toronto and that between one third and two thirds of commuters use public transit for their trip — depending on the municipality (TRBoT 2020, 28). More than a decade ago, the OECD *Territorial Review of Toronto* documented that traffic congestion cost the city over $3 billion dollars annually in terms of lost productivity and the problem has only increased since (OECD 2009). Given the growing integration of the regional economy, with its increasingly integrated commuting patterns, and the central role

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[18] If one adds the Hamilton and Kitchener-Waterloo CMAs to create what is sometimes referred to as Canada's Innovation Corridor, this numbers rise to 59% and 25% of Ontario's and Canada's GDP. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610046801)

that the city of Toronto plays in anchoring the broader regional economy, maintaining the physical and operating quality of Toronto's public transit system is critical for the future vitality of the city, the broader regional economy, and indeed, much of the province as well.

The following sections provide an overview of the economic geography of Toronto's urban economy, the key phases of its development over the last three quarters of a century and the current diversity of its economic structure. Toronto emerged at the end of World War II as the anchor for the industrial economy that had supported Canada's war effort for the previous seven years. Yet it still lagged significantly behind Montreal as the country's principal urban economy. Over the next three decades it gradually emerged as the primary urban centre in the country due to the dynamic flow of inward investment into southern Ontario, driven in part by the signing of the Auto Pact with the US in 1965, the strong flow of immigration into the region, and the shift of major financial institutions to Toronto in the 1970s. By the end of the century, it entered what has been termed its Fourth Era of postwar growth, which continues to the present. The current era is marked by Toronto's strength in a diverse range of economic sectors, including finance, cultural and creative industries, manufacturing, information and communication technologies and biomedical and health technologies.

The next section deals with Toronto's transition over the past decade and a half since the global financial crisis of 2008-09. Over this period, Toronto's economy has experienced a steady increase in the number of technology start-ups based in the city, anchored in part by the dense network of incubators and accelerators spread throughout the city and the region. It has also been the recipient of a strong burst of inward investment as the divisional offices of leading global MNEs have expanded their R&D mandates to tap into Toronto's recognized strengths in digital technology, especially machine learning and deep learning, with many of them relocating corporate head offices from south of the border to Toronto or opening high-end research facilities. Much of this investment has been driven by the strength of Toronto, and the broader region's dense network of post-secondary teaching and research institutions.

The last section deals with the increasingly integrated nature of the broader regional economy and the extent to which the public transit system operated by the TTC is essential, not just to facilitate the movement of people within the boundaries of the city itself, but equally to anchor the transit system of the entire regional economy, as businesses and people increasingly need to move both within Toronto, but also between Toronto and its surrounding urban centres, which together constitute an integrated regional economy. Failure to appreciate the critical role played by the TTC in anchoring the broader economy that contributes to Toronto's economic vitality, could have negative consequences, both for the city and the region, indeed, even for the Province itself.

4.2 Toronto's Fourth Era

Toronto's economy is the largest in Canada and the most economically diverse. It differs significantly from the other leading metropolitan centres in the country in terms of the breadth and diversity of its economic structure. One analysis commented that "the Toronto region has become the country’s preeminent metropolis, its dominant economic engine as well as innovation milieu, as well as its principal gateway to the rest of the world” (Bourne, Britton, and Leslie 2011, 236). The Toronto region constitutes the metropolitan core of Ontario’s regional innovation system, situated at the centre of the dense urban network extending through much of southwestern Ontario. The regional economy draws on a dense pool of talented and highly skilled labour to drive its continued growth, a labour market fed, in turn, by a steady flow of migration, with Toronto absorbing almost 40 per cent of all immigrants to Canada (Wolfe and Bramwell 2016).

Toronto’s emergence as the preeminent city region in the country marks a shift from its position as the major manufacturing hub in Southern Ontario at the end of World War II through four major eras of growth in the post-war period to its current position as a centre for higher-order business and financial services as well as research-intensive manufacturing activity. Since the turn of the millennium Toronto has entered its Fourth Era of postwar growth. Demarcated by the growing integration of the urban core within the broader regional economy, this era reflects the emergence of Toronto as a broadly based service economy with a growing concentration in knowledge-intensive business and financial services and the cultural and creative industries (Boston Consulting Group 1995).

This shift in the economic basis of Toronto’s economy is part of a broader transition in the economic structure of leading global cities, marked by the steady decline of traditional manufacturing activity, largely replaced by the expansion of office and service employment in sectors that rely on higher level cognitive and cultural labour inputs, an expansion that is increasingly concentrated in the central core of larger city regions. At the same time, the boundary between traditional sectors of the economy is shifting as innovation blurs the distinction between manufacturing and service-oriented activity. While many industrial activities still occur in identifiable sectors staffed by industry-specific occupations, many of the knowledge-intensive activities associated with new and emerging sectors of the economy are less easily categorized. Scott describes shifts in economic activity in terms of an emerging “cognitive-cultural economy” where leading-edge economic growth and innovation are driven by “technology-intensive manufacturing, diverse services, ‘fashion-oriented neo-artisanal production,’ and cultural products industries” (Scott 2007, 1466).

Consistent with this transition, the leading sectors in Toronto’s Fourth Era economy are concentrated in the knowledge and design intensive sectors around business and financial services, some core manufacturing sectors, including automotive and computers, the biopharmaceutical and biotechnology sectors, as well as the cultural, creative and design-intensive sectors that make intensive use of ICTs in a wide range of activities. The sectoral concentrations of Toronto’s regional economy increasingly lie in areas that involve higher-order business functions in global services as well as knowledge- and design-intensive activities.

The dramatic reconfiguration of the economic base and the occupational structure of metropolitan areas is most strikingly evident in urban architecture and restructuring of downtowns. Redesign of the physical space around central business districts and urban cores are being adapted for use in a growing range of cognitive-cultural activities. Old industrial factories and warehouses are being re-purposed for use in a wide range of cultural and design-intensive activities and numerous sites in the downtown core are being redeveloped. Potentially even more significant is the shift of real estate development eastward along the waterfront towards the redeveloped mouth of the Don River and beyond. Increasingly visible and idiosyncratic high rise office towers are evidence of the dramatic intensification of land use, often reflecting the aesthetic status afforded to an international cadre of star architects, whose unique designs are partly intended to bestow a distinctive character on large urban agglomerations aspiring to 'global city' status (Scott 2013; Scott 2014). The shifting land use patterns in the downtown core of cities in the cognitive-cultural economy tends to place greater demands on the urban transit systems responsible for moving commuters in and out of the core. While the pandemic clearly altered travel to work patterns (but with continued high usage of surface transit especially in the inner suburbs), the continuing pace of real estate development in the downtown core and along Toronto's waterfront suggests that key investors are betting on a return to more traditional work patterns.

4.3 Toronto's Changing Status in Global Innovation Networks

Over the past decade, as the economy recovered from the global financial crisis of 2008-09, announcements by leading multinational enterprises (MNEs) regarding inward investment into the Toronto region signalled a shift in their approach. Toronto's economy, especially in the software-intensive ICT sector and the rapidly evolving auto sector, has followed a developmental trajectory that corresponds to the shift in approach, based on new competence creating MNE strategies (Cantwell 2017). The Toronto Innovation Corridor has also experienced a dramatic expansion in the number of start-up and scale-up firms in the technology sector, especially software, as well as high growth service firms that have attracted record inward flows of venture capital, reaching a new peak in 2021 (McKinsey and Company 2016; Avison Young 2019). Concurrently, the divisional offices of leading global MNEs, headquartered in the region, have expanded their R&D mandates to tap into recognized strengths in digital technology, especially machine learning and deep learning, many of them relocating corporate head offices from south of the border to Toronto or opening high-end research facilities, both in the downtown core, as well as in other municipalities across the region. This shift reflects the structural break around 2008, based on radical innovations in cloud computing, software platforms, mobile applications, and the growing shift in ICT functionality from hardware to software (Shih 2015; Kenney, et al. 2019).

Several factors account for the changed approach to inward investment by MNEs in Toronto. A key attractor is Toronto's standing as a leading source of cutting-edge research and knowledge exploration. Both the city of Toronto and the broader city-region are home to a dense network of educational and research institutions, with particular strength in medical and biomedical research, as well as a number of traditional engineering fields and computer science. The Toronto Innovation Corridor is home to 18 post-secondary institutions, including 10 Universities and 8 Colleges of Applied Arts and Technology. The region is noted for its world-leading research and technology centres, housed both at these post-secondary institutions and in partnership with some of the companies located in the region (McKinsey and Company 2016; Avison Young 2019). Particularly noteworthy is the rising standing of its research capabilities in core technologies associated with the emerging technology paradigm, including cloud computing, big data and data analytics, and artificial intelligence and machine learning. This sectoral concentration in the regional economy draws on a dense pool of talented and highly skilled labour to drive their continued growth.

Equally important for companies interviewed was the deep talent pool available in the region and the steady stream of graduates from post-secondary institutions. Given the fact that Toronto has also been a magnet for inward migration, absorbing almost 40 per cent of all immigrants to Canada and with foreign-born residents accounting for 48 per cent of the region's population in the latest census, the steady growth of the local talent pool provides a strong stimulus for the growth of those sectors that comprise Toronto's expanding cognitive-cultural economy. In addition to inward immigration, the talent pool is fed by the more than 400,000 students enrolled across 18 post-secondary institutions. Particularly attractive has been the growth in STEM programs from 83,000 to more than 110,000 students in 2018, including Computer Science, Mathematics and Faculties of Applied Sciences and Engineering (Toronto Global 2018, 24–26). Toronto ranks first in Canada on Tech Talent by a wide margin, with 250,000 tech workers employed in the Corridor, representing 8.8 per cent of all employment, accounting for more than a quarter of all tech workers in Canada. The tech employment pool, including the categories of software developers, computer support, database and system analysts, and computer and information system managers, grew by 66,900 workers from 2014 to 2019, for a 5-year growth rate of 36.5% (CBRE Research 2021).

Toronto's diverse economic structure also generates potential for numerous synergies across different industry sectors or verticals. Its standing as one of the top twenty financial services centres globally and high ranking in North America is cited as a key attractor by many firms. It is a major market for the purchase of IT products and services and a good location to develop and test new products, as well as to tap into the burgeoning ecosystem of software and Fintech firms developing their own products and services (Toronto Financial Services Alliance 2017). In addition to the expanding flow of inward investment by global MNEs, Toronto has also experienced a dramatic expansion of its domestic start-up and scale-up firms in the technology sector. Toronto's high technology cluster, comprising both ICT manufacturing and service employment, constitutes a major component of the city-region's economy, employing more than 178,000 people in over 11,000 firms according to the latest census data (2016) and indeed an even larger tech economy if ICT-intensive employment in other sectors is included (TechToronto 2016).

However, the cluster-specific data by themselves do not reveal the full dimensions of the transformation under way, merely a sustained growth in ICT employment. In 2016 and 2017, Startup Genome counted 1,901 and 1,536 active start-ups recorded in the region, respectively, making Toronto the largest start-up ecosystem in Canada and a relatively large one globally

(Startup Genome, 2017; 2018). As confirmation of its new status, since the mid-2000s Toronto has ranked as one of the largest technology clusters in North America, after the San Francisco Bay Area and New York (Toronto Global 2018), which is confirmed in the latest ranking of tech talent centres by CBRE Research (2021). Similar trends exist across other technology start-up scenes (Silicon Valley, New York City, London, and Berlin), but the effects manifest differently, and it is the context-specific differences that lies at the heart of this research.

4.4 The Economic Importance/Impact of the TTC in the Broader Toronto Region Context

Regional government in the Greater Toronto Area stands in sharp contrast to that in other leading metropolitan regions in Canada. In 1997 the Ontario Government rejected the recommendation of the Task Force on the Greater Toronto Area to establish a regional level of government that would correspond more appropriately with the economic boundaries of the Greater Toronto Area and, instead, created the current City of Toronto, which covers only a small portion of the rapidly growing regional economy, thus perpetuating the divide between the '416' inner core of the city and the '905' belt of surrounding suburbs. In 2007, the landscape of regional transportation coordination changed with the establishment of the Greater Toronto Transportation Authority (GTTA), now known as Metrolinx. The mandate of the organization set out by provincial legislation states that the corporation is responsible for providing leadership in the coordination, financing, planning and development of a multi–modal transportation network that conforms to the provincial plan for the development of the broader region.

Metrolinx was not originally envisioned to be an integrated operator of transit systems, but rather as a coordinating body and potential forum through which inter-regional transit issues could be addressed. However, the assumption of responsibility by Metrolinx for the construction of new rapid transit developments in Toronto has both expanded its mandate and removed the TTC from responsibility for the capital cost associated with new transit infrastructure. However, the TTC will be responsible for assuming the operating cost of these new lines once they are completed and will also face additional pressure on its existing transit system as the new lines will bring increased numbers of riders into the city and will likely increase demands on other parts of the existing transit network. The TTC will be expected to absorb the operating costs associated with maintaining both the new transit infrastructure that is being added, as well as handling the increased upkeep and maintenance from the rise in demand on its existing transit network. On top of the fiscal pressures associated with meeting this rising level of demand, the TTC can expect to face steadily rising fiscal pressures associated with the intensification of land use in the downtown core arising from the inward flow of investments associated with the expansion of the cognitive cultural economy, as well as the potential future expansion of urban development eastward past the Don River, with the pressure for new transit services this development will create.

Overall, the regional economy of the Toronto area remains hampered by the lack of region-wide administrative structures to coordinate economic development strategies. The critical position of the city of Toronto at the core of this dynamic region-wide economy brings both numerous economic benefits in terms of steadily expanding levels of inward investment and intensified real estate development in the downtown core and other key parts of the city, but also associated costs in terms of providing critical transit services needed to accommodate the increased flow of commuters across the city to and from their places of work. Without the continued investment needed to maintain the operating quality and efficiency of the transit system, the city risks undermining the very basis for its future economic prosperity and success.

Chapter 5

Transit Ridership: Moving People; Making Cities Work

Prof. Eric J. Miller

Professor, Department of Civil and Mineral Engineering
Director, Mobility Network at the University of Toronto School of Cities

5.1 Introduction

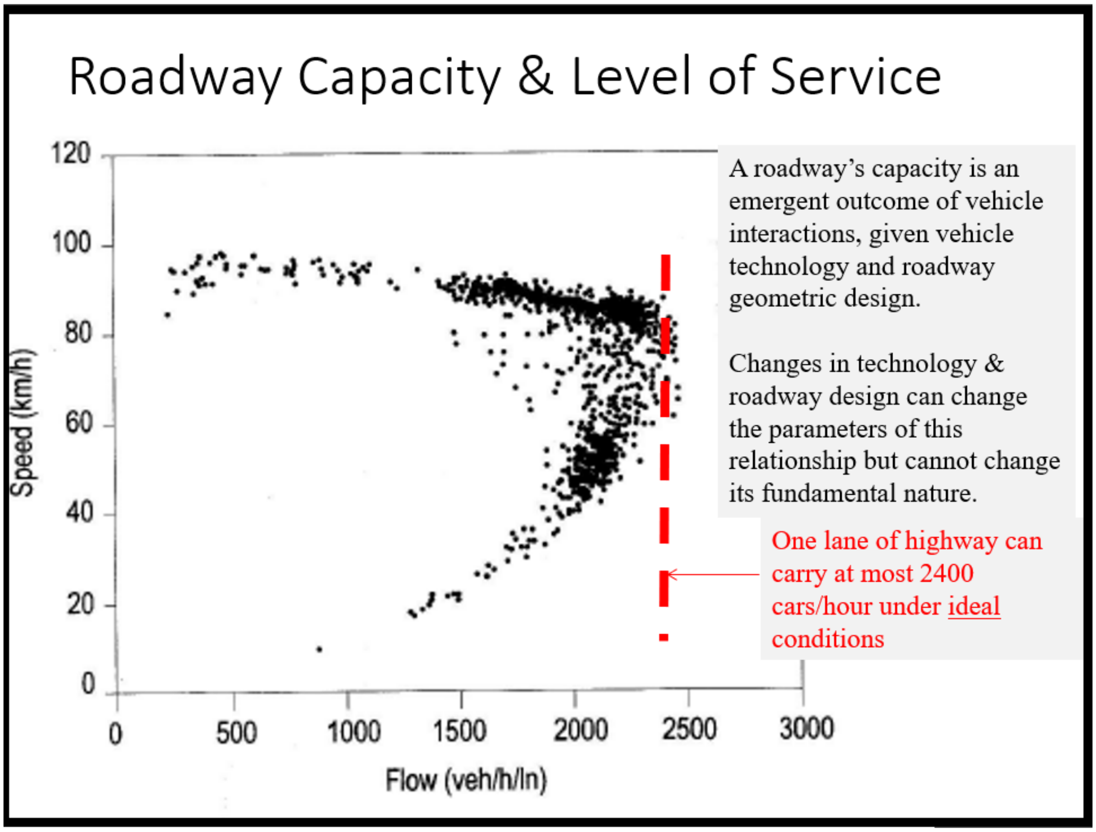
This chapter first presents in Section 5.2 the fundamental engineering principles underlying all transportation systems design and operations, which define what is physically possible and not possible to do within road and transit systems. It is essential for policy- and decision-makers to understand these basic principles when deciding upon transit operating and capital investment decision-making. Section 5.3 then presents an analysis of 2016 TTC ridership and mode shares to demonstrate the fundamentally essential role that the TTC plays within Toronto in ensuring that the city can function efficiently and productively on a daily basis.

5.2 The "Physics of Transportation"

Over and above environmental and social equity concerns (discussed in detail in Chapters 7 and 8), public transit is a fundamental prerequisite for a large urban area, since a solely car-based transportation system simply cannot cope with the density and volume of travel required to keep the urban area efficiently and successfully functioning on a day-to-day basis. This is especially true in order to maintain a strong and dynamic core area, which is a key characteristic of successful global cities, including Toronto. But it is also true for suburban portions of the city and region, which often experience some of the worst roadway congestion in the region due to lack of an adequate transit alternative.

Figure 5.1 presents real-world data illustrating what is known as the "fundamental equation of traffic flow". It plots observed speeds of a single segment of a highway versus the volume of traffic using this segment. As illustrated in this figure, as traffic volume increases, speeds drop slowly due to increasing congestion. A critical point, however, is reached, at a flow level of about 2,400 cars/hour/lane[19], which represents the maximum flow rate that is physically possible to move through this road segment. That is, it is the *capacity* of the highway segment to process arriving vehicles. As the flow arriving at the segment increases (as often occurs twice daily during weekday peak periods), the flow actually "breaks down" into a "traffic jam" (with which all Toronto residents are very familiar) and not only do speeds fall dramatically, but the actual flow (throughput) for the segment drops considerably as well.

This well-known behaviour of traffic flow on our roadways is a function of roadway geometry, vehicle performance (acceleration and deceleration capabilities) and driver behaviour. It represents the upper bound on the capacity of our road system to move vehicles and, hence, the people (and goods) in them. The only way to increase the system capacity is to build more roads. But even if we were willing to accept the cost this would mean in terms of construction costs, land consumption and environmental degradation (greenhouse gas and pollution emissions, etc.), it simply is physically impossible to build enough roadways to serve the millions of trips made daily withing the city and the region.



Roadway Capacity & Level of Service

A roadway's capacity is an emergent outcome of vehicle interactions, given vehicle technology and roadway geometric design.

Changes in technology & roadway design can change the parameters of this relationship but cannot change its fundamental nature.

One lane of highway can carry at most 2400 cars/hour under ideal conditions

Figure 5.1: The Speed-Flow "Fundamental Diagram" for a Typical Highway Segment (Source: Miller, 2014)

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[19] Under ideal conditions. Most highways operate at lower maximum flow rates (capacities) than this. Urban streets have much lower capacities, typically about 900 vehicles/lane/hour. (TRB, 2010).

While “active” modes of travel (i.e., walking and biking) clearly have a role to play in moving people over shorter distances, these alone are not sufficient to keep the city moving. Effective, efficient public transit must exist to fill the gap. As illustrated by Figure 5.2, well designed transit services can carry far more persons per hour than auto-based roads. The capacities shown in this figure are representative of what can be achieved. Actual service capacities will vary by the “mode” of the service (bus, streetcar, subway, etc.), its guideway design (on-street shared right-of-way operations typical of local buses and streetcars vs. dedicated / exclusive right-of-way operations for BRT[20], LRT[21], subway and commuter rail), individual vehicle capacities and transit route service frequencies. But clearly, the capability of public transit to carry far more people per line segment far exceeds that of the auto. In particular, note that the morning peak-period southbound capacity of the TTC’s Line 1 subway into the downtown[22] is the equivalent of approximately **26 lanes of highway**. I.e., if Line 1 did not exist, the equivalent of approximately **8-9 additional Gardner Expressways or Don Valley Parkways** would be required to provide the same capacity into the downtown. Clearly this is beyond any notion of feasibility. Thus, without Line 1 (let alone the extensive streetcar and bus network serving the downtown which adds enormous additional people-moving capacity), the Toronto downtown as we know it simply could not exist.

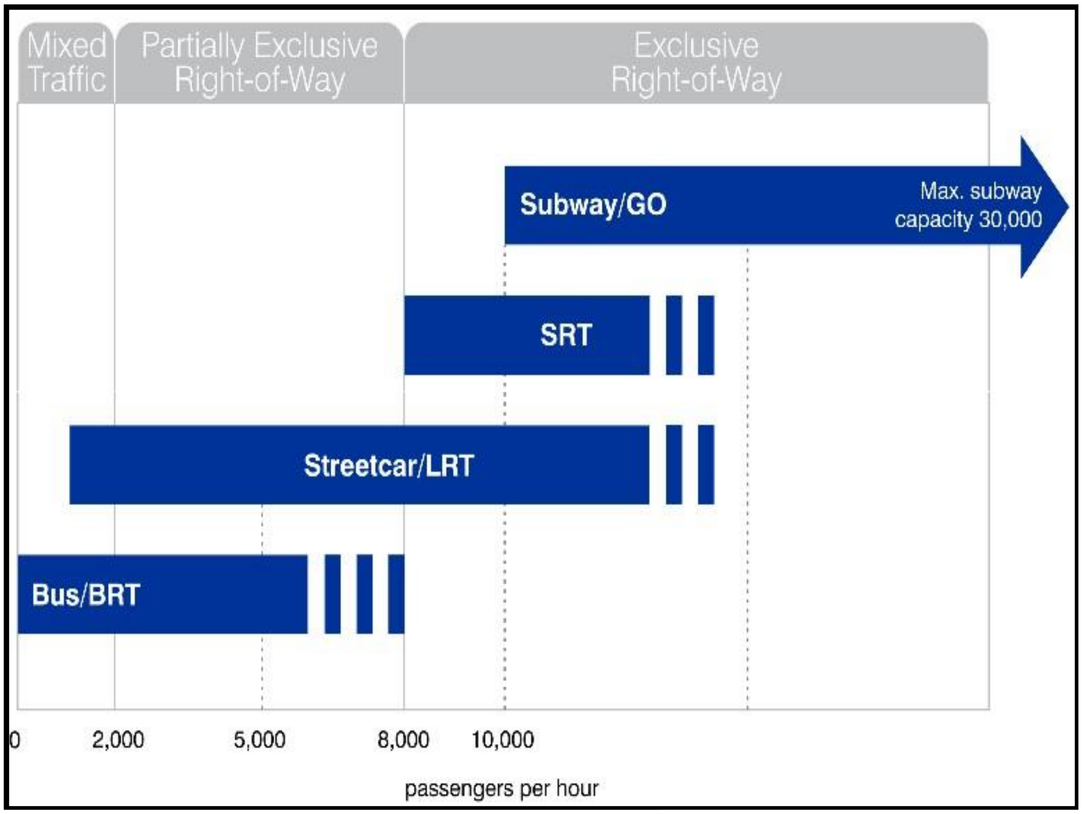

Figure 5.2: Typical Transit Line Capacities, Various Types of Service (Source: Miller, 2014)

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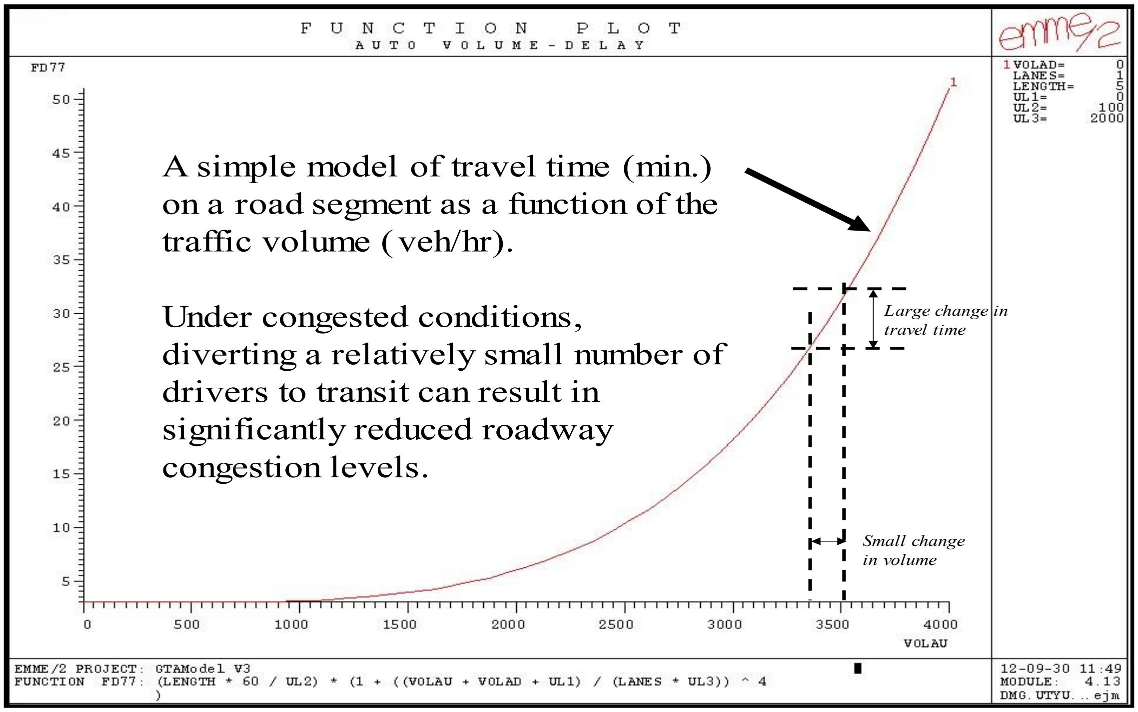
[20] Bus rapid transit.

[21] Light rail transit. E.g., “streetcar” type vehicles operating one exclusive rights-of-way. “Light” refers to the size of the transit car relative to the “heavy” vehicles that are characteristic of subways and commuter rail lines.

[22] Counting both the University and Yonge components of Line 1.

Clearly, not every trip in a large urban region can be served by transit, for a variety of reasons. But a well-designed and funded transit that is competitive with the auto with respect to travel times and service convenience can divert many trips from auto to transit, resulting in both fewer adverse impacts (e.g., GHG and pollution emissions) and less congestion of the road system. Thus, investment in transit is a "win-win" for both transit users and auto drivers. Figure 5.3 illustrates this effect, in which it is seen that a relatively modest diversion of trip-makers from auto to transit can result in a significant reduction in roadway congestion levels (and, again, pollution reductions, etc.).



A simple model of travel time (min.) on a road segment as a function of the traffic volume (veh/hr).

Under congested conditions, diverting a relatively small number of drivers to transit can result in significantly reduced roadway congestion levels.

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EMME/2 PROJECT:  GTAModel V3
FUNCTION  FD77:  (LENGTH * 60 / UL2) * (1 + ((VOLAU + VOLAD + UL1) / (LANES * UL3)) ^ 4
                 )
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Figure 5.3: Congestion Reduction Due to Diversion of Trips to Transit

5.3 Pre-Pandemic TTC Ridership and Mode Shares

5.3.1 Introduction

This section illustrates the critical importance of the TTC as a mover of people within Toronto and the GTHA by presenting key travel statistics extracted from the 2016 Transportation Tomorrow Survey (TTS). The TTS is one of the world's largest urban travel surveys. It is conducted every five years to gather a comprehensive snapshot of travel behaviour within the GGH to support transportation planning analysis and modelling within the region. Information for one weekday's worth of travel by all household members (11 years old or older) within a random sample of 5% of all GGH households provides a detailed, high-quality description of trip-making by mode (car, transit, etc.), trip purpose (work, school, etc.,) time of day, location (trip origins and destinations) and trip-maker socio-economic characteristics (income, auto ownership, age, employment status, etc.).[23]

The 2016 survey is the most recent one currently available for analysis.[24] It provides a useful representation of pre-pandemic travel conditions in the region. While current travel in the region is still evolving as we "recover" from the pandemic and new travel patterns emerge, it is generally expected that travel will gradually return to approximately pre-pandemic levels, despite possible long-term shifts in "working from home", etc. This is especially likely to be the case given the expected continuing population growth in the city and the region, which will generate additional travel demand in the years to come. Thus, the 2016 travel patterns provide a useful guide for planning for future year transit operations and investment, even while current ridership levels continue to be suppressed due to lingering pandemic-induced effects. All data presented in the following tables in this section are extracted from the 2016 TTS.

5.3.2 2016 TTC Ridership and Mode Shares

Table 5.1 presents TTC transit trips and mode shares (percentage of total trips using the TTC) for all trip purposes by time of day (morning and afternoon peak periods combined, off-peak and total daily) by regional origin-destination (O-D) trips.[25] Trips with Toronto are highlighted in light green. "Planning District 1" (PD1),[26] the Toronto central area, is separated from the rest of the city due to its critical importance as the economic heart of the city, as well as a major generator of transit trips.

As indicated in this table approximately 1.5 million trips were made on a typical fall weekday on the TTC in 2016. Points to note from this table include the following.

- Approximately 61% of all trips made to and from PD1 from/to the rest of the city use the TTC. This illustrates the extreme importance of the TTC to the health and vitally of the Toronto downtown. It also illustrates that building and upgrading transit services to the

downtown is not "just a downtown issue". These services are critical to suburban residents requiring access to central area jobs, stores, services, etc.

- The overall peak-period TTC mode share of 22% for non-PD1 trips within the city of Toronto is high by North American standards and illustrates the importance of the TTC for providing accessibility to jobs, etc. for residents across the entire city.
- The 24.5% TTC mode share for within-PD1 trips reflects the high walking (51.9%) and biking (8.1%) mode shares within the dense central area.
- Off-peak mode shares (and hence daily total mode shares as well) are only marginally lower than the peak period values. This reinforces the importance of the TTC as an all-day, all-purpose mover of people.

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[23] For additional documentation of the TTS, see Malatest (2018a,b),

[24] The next survey in the series should have happened in the fall of 2021, but was postponed due to the effects of the ongoing pandemic. This survey is currently (fall, 2022) underway.

[25] For the total trips being made by time of day and regional O-D, see Table I.1 in Appendix I.

[26] See Figure 54.4 for the definition of PD1.

- TTC mode shares for trips to/from PD1 and the GTHA "905" regions outside Toronto are also high, especially for York and Peel regions. Note that these numbers do not include trips by GO Rail or GO Bus. If these were to be included, then the peak period mode shares would rise to 64.5%. These numbers again illustrate the importance of transit in providing the Toronto central area with access the regional labour pool necessary to support its extremely high employment levels and productivity.

Table 5.1: GTHA TTC Trips & Mode Shares by Time of Day and Regional O-Ds

2016 GTHA Transit Trips Using the TTC

(a) Morning & Afternoon Peak Periods

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	55,640	185,535	3,409	18,043	10,606	2,048	903	276,184
Rest of Toromto	197,731	338,864	1,968	15,030	9,086	1,547	468	564,694
Durham	3,644	2,081	100	0	0	0	0	5,825
York	19,412	14,864	174	2,207	64	0	0	36,721
Peel	12,138	9,185	0	123	289	16	0	21,751
Halton	2,670	1,588	0	0	16	87	0	4,361
Hamilton	889	292	0	0	0	0	0	1,181
Total	292,124	552,409	5,651	35,403	20,061	3,698	1,371	910,717

(b) Off-Peak (Midday; Evening; Night) Periods

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	45907	119109	1136	7038	5251	894	212	179,547
Rest of Toromto	109125	277416	1276	8837	5334	669	238	402,895
Durham	1191	1267	10	30	0	0	0	2,498
York	5242	9245	44	2172	121	0	0	16,824
Peel	3952	5236	0	98	370	0	0	9,656
Halton	535	572	0	0	31	0	0	1,138
Hamilton	312	524	0	0	0	0	0	836
Total	166,264	413,369	2,466	18,175	11,107	1,563	450	613,394

(c) 24-Hour (All-Day)

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	101547	304644	4545	25081	15857	2942	1115	455,731
Rest of Toromto	306856	616280	3244	23867	14420	2216	706	967,589
Durham	4835	3348	110	30	0	0	0	8,323
York	24654	24109	218	4379	185	0	0	53,545
Peel	16090	14421	0	221	659	16	0	31,407
Halton	3205	2160	0	0	47	87	0	5,499
Hamilton	1201	816	0	0	0	0	0	2,017
Total	458,388	965,778	8,117	53,578	31,168	5,261	1,821	1,524,111

2016 GTHA TTC Trip Mode Shares (% of O-D Total Trips)

(a) Morning & Afternoon Peak Periods

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	24.5%	61.3%	15.4%	36.7%	23.0%	11.8%	20.3%	41.3%
Rest of Toromto	60.9%	22.0%	3.5%	7.2%	6.4%	7.4%	10.1%	24.5%
Durham	15.7%	3.5%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%
York	35.1%	6.9%	0.6%	0.3%	0.1%	0.0%	0.0%	3.3%
Peel	23.7%	6.2%	0.0%	0.2%	0.0%	0.0%	0.0%	1.7%
Halton	14.0%	7.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
Hamilton	19.2%	6.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Total	41.5%	24.1%	1.0%	3.2%	1.6%	0.7%	0.3%	13.0%

(b) Off-Peak (Midday; Evening; Night) Periods

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	23.0%	54.0%	10.5%	27.6%	21.3%	11.8%	7.6%	36.6%
Rest of Toromto	54.8%	18.8%	3.0%	5.5%	4.9%	4.8%	4.6%	20.1%
Durham	12.4%	3.2%	0.0%	0.2%	0.0%	0.0%	0.0%	0.5%
York	26.8%	5.9%	0.3%	0.3%	0.4%	0.0%	0.0%	1.9%
Peel	19.6%	5.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.9%
Halton	8.7%	4.3%	0.0%	0.0%	0.1%	0.0%	0.0%	0.2%
Hamilton	10.9%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Total	36.4%	20.5%	0.4%	2.0%	1.0%	0.3%	0.1%	10.1%

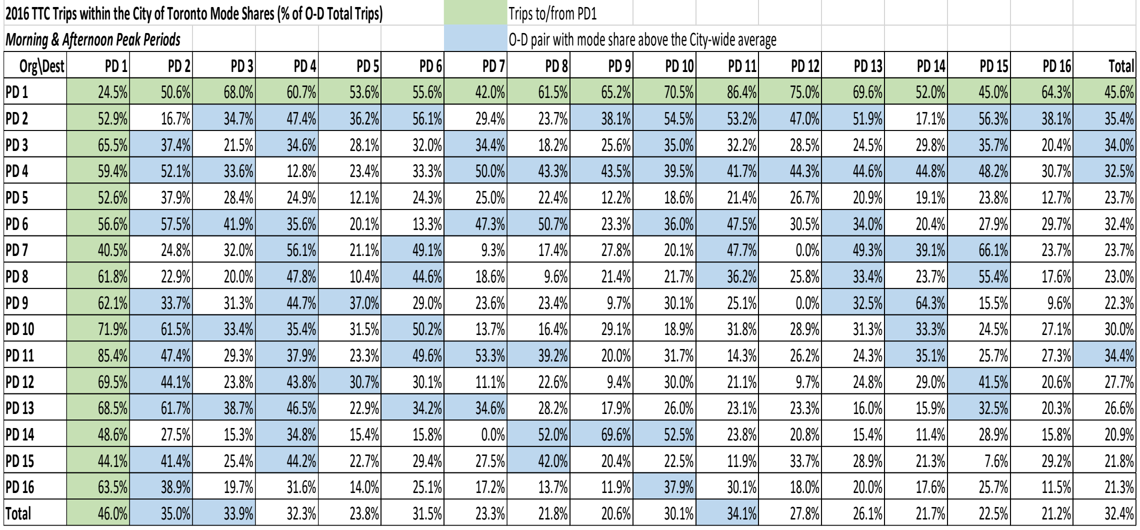
(c) 24-Hour (All-Day)

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	23.8%	58.2%	13.8%	33.6%	22.4%	11.8%	15.4%	39.3%
Rest of Toromto	58.6%	20.4%	3.3%	6.4%	5.7%	6.4%	7.2%	22.5%
Durham	14.7%	3.4%	0.0%	0.1%	0.0%	0.0%	0.0%	0.7%
York	32.9%	6.5%	0.5%	0.3%	0.2%	0.0%	0.0%	2.7%
Peel	22.6%	5.7%	0.0%	0.2%	0.0%	0.0%	0.0%	1.3%
Halton	12.7%	6.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Hamilton	16.1%	8.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Total	39.5%	22.4%	0.7%	2.7%	1.3%	0.5%	0.2%	11.7%

Table 5.2 expands on this analysis by breaking down TTC peak-period mode shares by planning district O-D pairs, where these planning districts are defined in Figure 5.4.[27] The key points to note from this table are:

- Very high TTC mode shares to/from PD1 exist across all portions of the city of Toronto, ranging from a low (but still very high in absolute terms) of 41% for PD7 (Mimico) to a high of 85% for PD11.
- The older, “inner city” areas of PDs 2, 3, 4 and 6, all also generally have high TTC mode shares.
- Above average mode shares also exist for many O-D trips throughout the city, notably in portions of Scarborough, Etobicoke and North York.
- Off-peak mode shares (see Table I.2 in Appendix I), while generally somewhat less than the peak numbers, are still high relative to North American standards, and display a similar pattern of cross-city transit dependency.

Table 5.2: TTC Peak-Period Mode Shares by Planning District ODs



2016 TTC Trips within the City of Toronto Mode Shares (% of O-D Total Trips) 🟩 Trips to/from PD1
Morning & Afternoon Peak Periods 🟦 O-D pair with mode share above the City-wide average

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	24.5%	50.6%	68.0%	60.7%	53.6%	55.6%	42.0%	61.5%	65.2%	70.5%	86.4%	75.0%	69.6%	52.0%	45.0%	64.3%	45.6%
PD 2	52.9%	16.7%	34.7%	47.4%	36.2%	56.1%	29.4%	23.7%	38.1%	54.5%	53.2%	47.0%	51.9%	17.1%	56.3%	38.1%	35.4%
PD 3	65.5%	37.4%	21.5%	34.6%	28.1%	32.0%	34.4%	18.2%	25.6%	35.0%	32.2%	28.5%	24.5%	29.8%	35.7%	20.4%	34.0%
PD 4	59.4%	52.1%	33.6%	12.8%	23.4%	33.3%	50.0%	43.3%	43.5%	39.5%	41.7%	44.3%	44.6%	44.8%	48.2%	30.7%	32.5%
PD 5	52.6%	37.9%	28.4%	24.9%	12.1%	24.3%	25.0%	22.4%	12.2%	18.6%	21.4%	26.7%	20.9%	19.1%	23.8%	12.7%	23.7%
PD 6	56.6%	57.5%	41.9%	35.6%	20.1%	13.3%	47.3%	50.7%	23.3%	36.0%	47.5%	30.5%	34.0%	20.4%	27.9%	29.7%	32.4%
PD 7	40.5%	24.8%	32.0%	56.1%	21.1%	49.1%	9.3%	17.4%	27.8%	20.1%	47.7%	0.0%	49.3%	39.1%	66.1%	23.7%	23.7%
PD 8	61.8%	22.9%	20.0%	47.8%	10.4%	44.6%	18.6%	9.6%	21.4%	21.7%	36.2%	25.8%	33.4%	23.7%	55.4%	17.6%	23.0%
PD 9	62.1%	33.7%	31.3%	44.7%	37.0%	29.0%	23.6%	23.4%	9.7%	30.1%	25.1%	0.0%	32.5%	64.3%	15.5%	9.6%	22.3%
PD 10	71.9%	61.5%	33.4%	35.4%	31.5%	50.2%	13.7%	16.4%	29.1%	18.9%	31.8%	28.9%	31.3%	33.3%	24.5%	27.1%	30.0%
PD 11	85.4%	47.4%	29.3%	37.9%	23.3%	49.6%	53.3%	39.2%	20.0%	31.7%	14.3%	26.2%	24.3%	35.1%	25.7%	27.3%	34.4%
PD 12	69.5%	44.1%	23.8%	43.8%	30.7%	30.1%	11.1%	22.6%	9.4%	30.0%	21.1%	9.7%	24.8%	29.0%	41.5%	20.6%	27.7%
PD 13	68.5%	61.7%	38.7%	46.5%	22.9%	34.2%	34.6%	28.2%	17.9%	26.0%	23.1%	23.3%	16.0%	15.9%	32.5%	20.3%	26.6%
PD 14	48.6%	27.5%	15.3%	34.8%	15.4%	15.8%	0.0%	52.0%	69.6%	52.5%	23.8%	20.8%	15.4%	11.4%	28.9%	15.8%	20.9%
PD 15	44.1%	41.4%	25.4%	44.2%	22.7%	29.4%	27.5%	42.0%	20.4%	22.5%	11.9%	33.7%	28.9%	21.3%	7.6%	29.2%	21.8%
PD 16	63.5%	38.9%	19.7%	31.6%	14.0%	25.1%	17.2%	13.7%	11.9%	37.9%	30.1%	18.0%	20.0%	17.6%	25.7%	11.5%	21.3%
Total	46.0%	35.0%	33.9%	32.3%	23.8%	31.5%	23.3%	21.8%	20.6%	30.1%	34.1%	27.8%	26.1%	21.7%	22.5%	21.2%	32.4%

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[27] Due to the size of the tables, the TTC trips and other mode share tables, as well as the total trip tables are provided in Tables I.2 and I.3 in Appendix I.

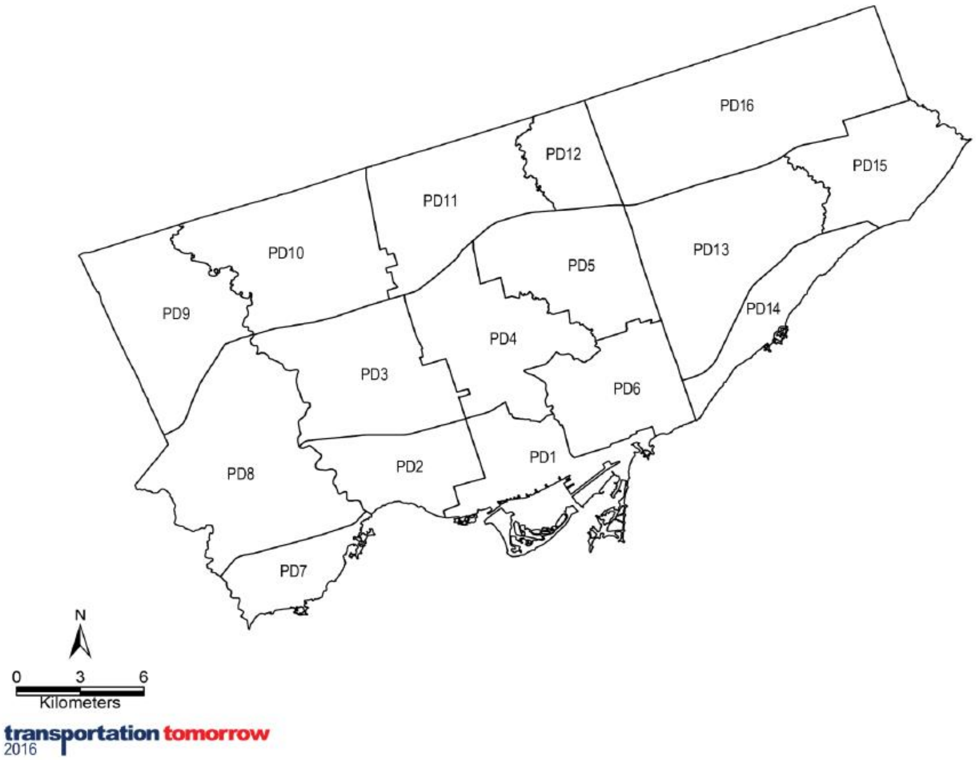
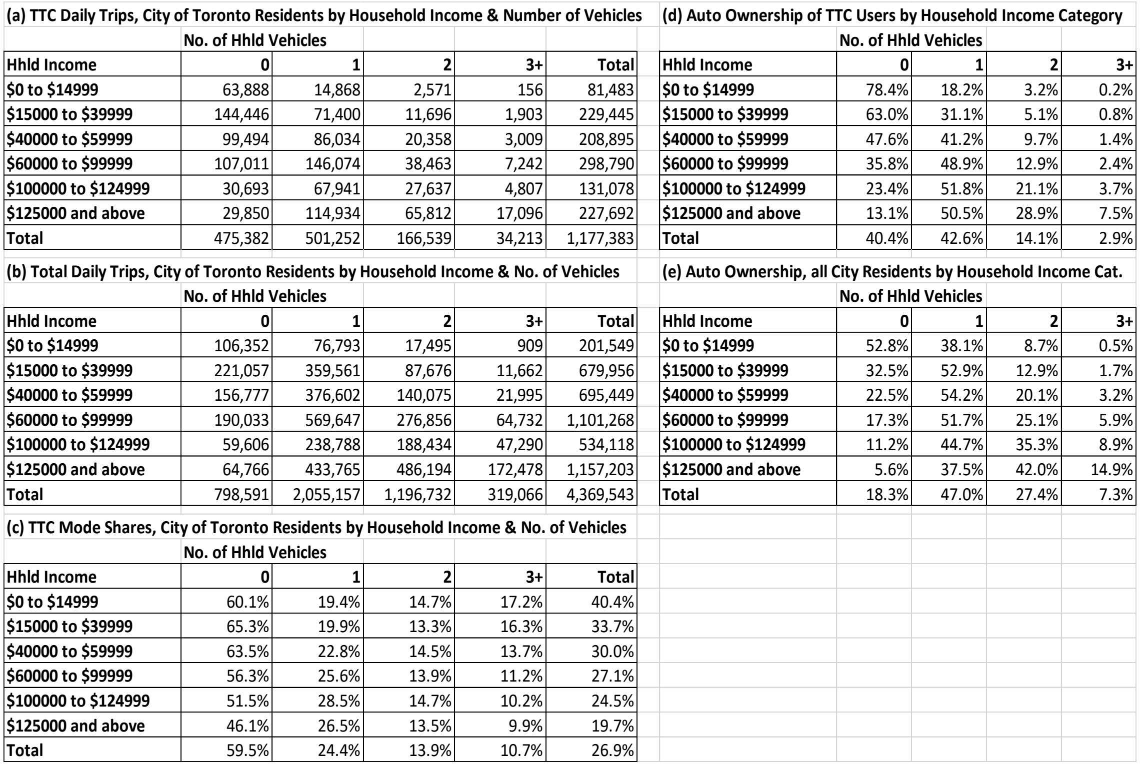


Figure 5.4: City of Toronto Planning Districts (Source: Malatest, 2018b)

Table 5.3 digs further into TTC usage by tabulating daily TTC and total trips by Toronto residents, categorized by household income and auto ownership levels. Not surprisingly, both income and auto ownership are important determinants of transit usage. Points to note from this table include:

- Zero-car households are very transit-dependent, regardless of income level, although transit mode shares do decline slightly among the higher income groups (Table 5.3(c)).
- Transit usage drops considerably once a household has at least one vehicle (Table 5.3(c)), with 83% of all TTC trips being made by households with zero or one vehicles (Table 5.3(d)).
- Overall, transit usage drops as household income increases (Table 5.3(c)), but this is to a considerable extent a function of increasing auto ownership with income (Table 5.3(e)).

Table 5.3: TTC Trips & Mode Shares by City of Toronto Residents by Household Income and Number of Household Vehicles



(a) TTC Daily Trips, City of Toronto Residents by Household Income & Number of Vehicles

	No. of Hhld Vehicles				
Hhld Income	0	1	2	3+	Total
$0 to $14999	63,888	14,868	2,571	156	81,483
$15000 to $39999	144,446	71,400	11,696	1,903	229,445
$40000 to $59999	99,494	86,034	20,358	3,009	208,895
$60000 to $99999	107,011	146,074	38,463	7,242	298,790
$100000 to $124999	30,693	67,941	27,637	4,807	131,078
$125000 and above	29,850	114,934	65,812	17,096	227,692
Total	475,382	501,252	166,539	34,213	1,177,383

(d) Auto Ownership of TTC Users by Household Income Category

	No. of Hhld Vehicles			
Hhld Income	0	1	2	3+
$0 to $14999	78.4%	18.2%	3.2%	0.2%
$15000 to $39999	63.0%	31.1%	5.1%	0.8%
$40000 to $59999	47.6%	41.2%	9.7%	1.4%
$60000 to $99999	35.8%	48.9%	12.9%	2.4%
$100000 to $124999	23.4%	51.8%	21.1%	3.7%
$125000 and above	13.1%	50.5%	28.9%	7.5%
Total	40.4%	42.6%	14.1%	2.9%

(b) Total Daily Trips, City of Toronto Residents by Household Income & No. of Vehicles

	No. of Hhld Vehicles				
Hhld Income	0	1	2	3+	Total
$0 to $14999	106,352	76,793	17,495	909	201,549
$15000 to $39999	221,057	359,561	87,676	11,662	679,956
$40000 to $59999	156,777	376,602	140,075	21,995	695,449
$60000 to $99999	190,033	569,647	276,856	64,732	1,101,268
$100000 to $124999	59,606	238,788	188,434	47,290	534,118
$125000 and above	64,766	433,765	486,194	172,478	1,157,203
Total	798,591	2,055,157	1,196,732	319,066	4,369,543

(e) Auto Ownership, all City Residents by Household Income Cat.

	No. of Hhld Vehicles			
Hhld Income	0	1	2	3+
$0 to $14999	52.8%	38.1%	8.7%	0.5%
$15000 to $39999	32.5%	52.9%	12.9%	1.7%
$40000 to $59999	22.5%	54.2%	20.1%	3.2%
$60000 to $99999	17.3%	51.7%	25.1%	5.9%
$100000 to $124999	11.2%	44.7%	35.3%	8.9%
$125000 and above	5.6%	37.5%	42.0%	14.9%
Total	18.3%	47.0%	27.4%	7.3%

(c) TTC Mode Shares, City of Toronto Residents by Household Income & No. of Vehicles

	No. of Hhld Vehicles				
Hhld Income	0	1	2	3+	Total
$0 to $14999	60.1%	19.4%	14.7%	17.2%	40.4%
$15000 to $39999	65.3%	19.9%	13.3%	16.3%	33.7%
$40000 to $59999	63.5%	22.8%	14.5%	13.7%	30.0%
$60000 to $99999	56.3%	25.6%	13.9%	11.2%	27.1%
$100000 to $124999	51.5%	28.5%	14.7%	10.2%	24.5%
$125000 and above	46.1%	26.5%	13.5%	9.9%	19.7%
Total	59.5%	24.4%	13.9%	10.7%	26.9%

Table 5.4 displays TTC and total daily trips by Toronto residents by trip purpose and gender.[28] Note that a "home-based" trip is one for which the trip-maker's home is either the origin or the destination of the trip (e.g., both a home-to-work and a work-to-home trip are home-based work trips). A non-home-based trip is thus one in which home is neither the origin nor destination (e.g., a trip from work to a shopping location). A "discretionary" trip is any trip for which work or school are not the non-home end of the trip (e.g., shopping). Points to note from this table include:

- Females are more likely to use transit than males, regardless of trip purpose, although the difference for school trips is very small (Table 5.4(c)).
- Female trip purposes are more likely to be for non-work/school purposes and less likely for work than for males, reflecting differences in household roles and labour force participation (Table 5.4(e)).
- While transportation policy often focusses on work trip commuting, these trips only represent a little over a third (36.4%) of total daily trips by Toronto residents, with school trips accounting for another 11.3% of trips. Thus, a majority of daily weekday trips (52.7%) are made for other trip purposes, serving a wide variety of people's needs (Table 5.4(e)).

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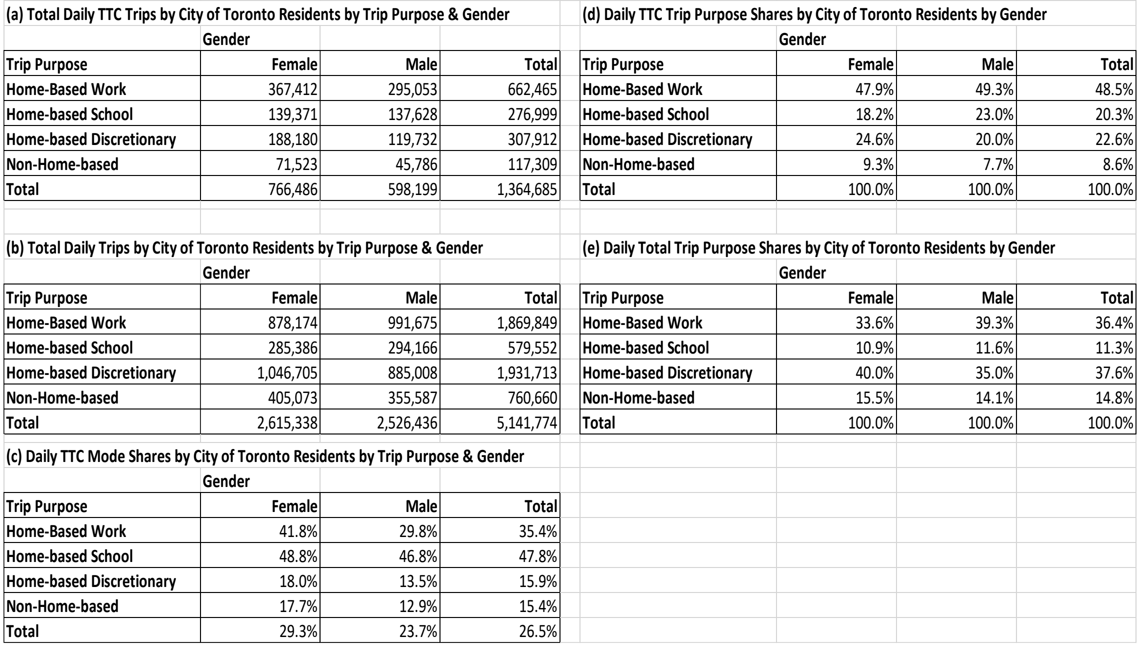
[28] In the 2016 TTS, "male" and "female" were the only two gender categories available from which respondents could choose. This has changed in the 2022 TTS currently underway.

- On the other hand, 48.5% of all TTC trips are home-based work trips and a further 20.3% are home-based school trips, indicating the importance of these two “markets” for TTC ridership.

Table 5.4: City of Toronto Residents’ Daily TTC & Total Daily Trips by Trip Purpose & Trip-Maker Gender



(a) Total Daily TTC Trips by City of Toronto Residents by Trip Purpose & Gender

	Gender		
Trip Purpose	**Female**	**Male**	**Total**
Home-Based Work	367,412	295,053	662,465
Home-based School	139,371	137,628	276,999
Home-based Discretionary	188,180	119,732	307,912
Non-Home-based	71,523	45,786	117,309
Total	766,486	598,199	1,364,685

(d) Daily TTC Trip Purpose Shares by City of Toronto Residents by Gender

	Gender		
Trip Purpose	**Female**	**Male**	**Total**
Home-Based Work	47.9%	49.3%	48.5%
Home-based School	18.2%	23.0%	20.3%
Home-based Discretionary	24.6%	20.0%	22.6%
Non-Home-based	9.3%	7.7%	8.6%
Total	100.0%	100.0%	100.0%

(b) Total Daily Trips by City of Toronto Residents by Trip Purpose & Gender

	Gender		
Trip Purpose	**Female**	**Male**	**Total**
Home-Based Work	878,174	991,675	1,869,849
Home-based School	285,386	294,166	579,552
Home-based Discretionary	1,046,705	885,008	1,931,713
Non-Home-based	405,073	355,587	760,660
Total	2,615,338	2,526,436	5,141,774

(e) Daily Total Trip Purpose Shares by City of Toronto Residents by Gender

	Gender		
Trip Purpose	**Female**	**Male**	**Total**
Home-Based Work	33.6%	39.3%	36.4%
Home-based School	10.9%	11.6%	11.3%
Home-based Discretionary	40.0%	35.0%	37.6%
Non-Home-based	15.5%	14.1%	14.8%
Total	100.0%	100.0%	100.0%

(c) Daily TTC Mode Shares by City of Toronto Residents by Trip Purpose & Gender

	Gender		
Trip Purpose	**Female**	**Male**	**Total**
Home-Based Work	41.8%	29.8%	35.4%
Home-based School	48.8%	46.8%	47.8%
Home-based Discretionary	18.0%	13.5%	15.9%
Non-Home-based	17.7%	12.9%	15.4%
Total	29.3%	23.7%	26.5%

Finally, Table 5.5 tabulates TTC and total daily trips by city of Toronto workers by occupation class and employment status. Note that these trips are for all trip purposes, not just the journey to/from work. Points to note from this table include:

- The Manufacturing/etc. occupation class has generally a much lower transit mode share than the “white collar” occupations, reflecting the dispersed nature of these workplaces (often in suburban location with relatively poor transit service) and the off-peak (“shift work” nature of many of these jobs’ start and end times (Table 5.5(c)).
- People working from home, either full- or part-time have much lower transit mode shares than people who work outside of the home (Table 5.5(c)).
- For people working outside of the home, part-time workers are more likely to be transit users (except for the Professional/etc. occupation group), presumably reflecting their generally lower income levels.
- Although Professional/etc. workers have a slightly lowest transit mode share overall relative to the other “white collar” occupation groups, this is the largest occupation class in the city (at least as measured by the TTS classification) and so this is an extremely important market for the TTC, representing almost exactly 50% of 2016 ridership (Table 5.5(a)).

Table 5.5: City of Toronto Workers’ TTC & Total Daily Trips by Occupation Class & Employment Status

(a) 2016 City of Toronto Workers Daily TTC Trips by Occupation Class & Employment Status

	Employment Status				
Occupation	**Full time**	**Home / Full time**	**Home / Part time**	**Part time**	**Total**
General Office/Clerical	128,846	1,914	1,484	27,656	159,900
Manufacturing/Construction/Trades	40,479	517	597	6,569	48,162
Professional/Management/Technical	408,434	9,465	6,461	41,765	466,125
Retail Sales and Service	135,066	4,305	2,575	117,521	259,467
Total	712,825	16,201	11,117	193,511	933,654

(b) 2016 City of Toronto Workers Daily Total Trips by Occupation Class & Employment Status

	Employment Status				
Occupation	**Full time**	**Home / Full time**	**Home / Part time**	**Part time**	**Total**
General Office/Clerical	356,204	11,696	13,556	71,161	452,617
Manufacturing/Construction/Trades	300,971	6,541	2,715	28,422	338,649
Professional/Management/Technical	1,567,996	81,844	40,914	163,849	1,854,603
Retail Sales and Service	498,423	37,727	18,147	267,516	821,813
Total	2,723,594	137,808	75,332	530,948	3,467,682

(c) 2016 City of Toronto Workers Daily TTC Mode Shares by Occupation Class & Employment Status

	Employment Status				
Occupation	**Full time**	**Home / Full time**	**Home / Part time**	**Part time**	**Total**
General Office/Clerical	36.2%	16.4%	10.9%	38.9%	35.3%
Manufacturing/Construction/Trades	13.4%	7.9%	22.0%	23.1%	14.2%
Professional/Management/Technical	26.0%	11.6%	15.8%	25.5%	25.1%
Retail Sales and Service	27.1%	11.4%	14.2%	43.9%	31.6%
Total	26.2%	11.8%	14.8%	36.4%	26.9%

Chapter 6

Economic Impacts of Public Transport Reliability

Dr. Willem Klumpenhouwer
Postdoctoral Fellow at Transit Analytics Lab at Mobility Network
Prof. Amer Shalaby
Professor, Department of Civil and Mineral Engineering
Director, Transit Analytics Lab at Mobility Network

The ability of a transit agency to deliver a consistent service is critical to its success as a viable transport system. A reliable service is easy to access, has short and consistent travel times, and arrives predictably (E. I. Diab, Badami, and El-Geneidy 2015). Service reliability is consistently shown to be strongly linked with ridership, and along with safety it forms the foundation of what customers need from a transit system (Peek and van Hagen 2002).

Service delay and unreliability can be roughly divided into two main categories: recurrent and non-recurrent delays/disruptions. Both can have a significant impact on the perceived and actual travel times and quality of the service.

As illustrated in Figure 6.1, non-recurrent delays happen with lower frequencies, but have larger impacts. These types of disruptions include subway track-level incursions, broken signals and switches, or other delays that result in a larger mobilization of bus bridging efforts. These incidents cause major one-time delays to passengers, however if they occur with more frequency, they can severely erode the confidence of the rider in the system.

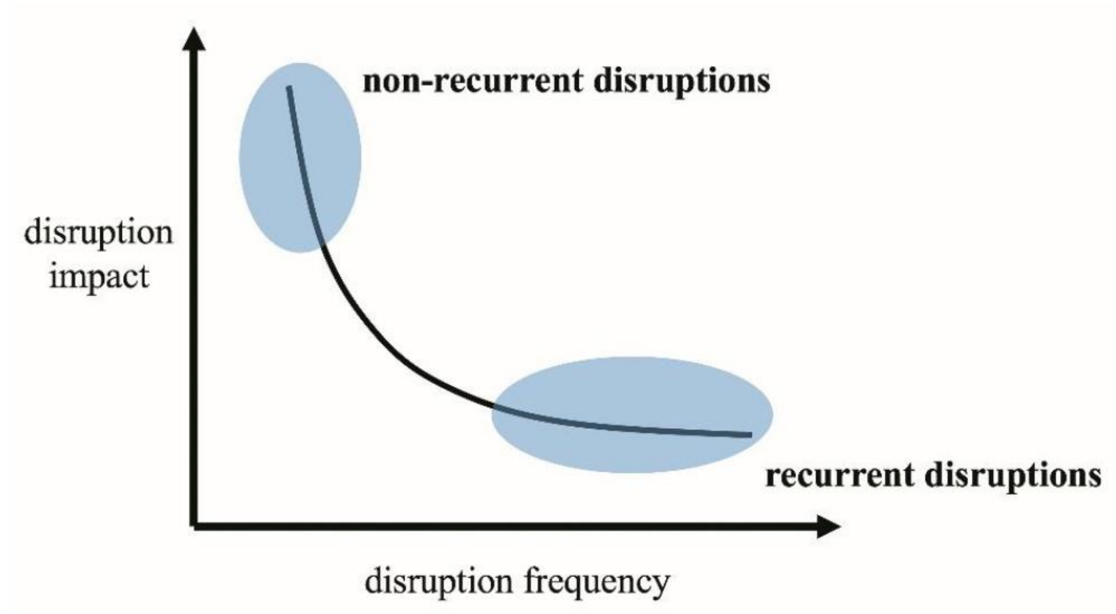


Figure 6.1: The Impact-Frequency Diagram for Recurrent and Non-Recurrent Disruptions. Diagram by Yap (2020)

Recurrent delays happen relatively constantly through a transport network. For a surface transit network, the most common sources of recurrent delay are interactions with vehicular traffic, variations in the passenger boarding times and loads at various stops, and weather. For portions of the network with relatively isolated rights of way (such as a subway system), recurrent delays are most often caused by variations in passenger boarding at stations, and differences between vehicle operators.

In this chapter we highlight how unreliable service translates to economic impact, provide some initial valuations of analogous systems in the United States. We then discuss broader direct and indirect impacts of delays in the system and describe how up-to-date infrastructure and state-of-good-repair can improve reliability and therefore reduce the economic loss it causes.[29]

6.1 Valuation of Additional Travel Time Caused by Unreliable Service

Despite its relative importance, the economic value and impact of day-to-day unreliability and service disruption has not been extensively calculated. Most studies to date focus on the direct costs of riders having to "pad" their travel schedule to account for randomness. This padding is lost time that is directly caused by the unpredictable travel times experienced by riders. This lost time can also have indirect costs to the economy at large due to missing productivity. Carrion and Levinson (2012) note in their review on approaches to valuate travel time that "the value of reliability is a 'newcomer' to [the] field", and that much of the value estimation comes

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[29] For more detailed information on the importance, impact, and management of reliability, see *Minutes Matter: A Bus Transit Service Reliability Guidebook* by the Transit Cooperative Research Program (2020).

largely from stated preference surveys.[30] While there is consensus that late or unreliable service is highly important to riders, specific valuations vary across the globe, as summarized by Vincent (2008):

International evidence relating to public transport reliability suggests large variations in reliability valuation, indicating valuations to be highly context-specific. On average, one minute of average lateness is valued around four times more than in-vehicle time (IVT). In terms of varying service reliability, the evidence suggests one minute of standard deviation of lateness is worth one minute of IVT. Valuations for waiting passengers are generally higher than for passengers on the service. Little evidence suggests any consistent differences by mode, time of day or trip purpose.

With these difficulties in mind, there have been a handful of studies attempting to place a dollar value on reliability:

- A 2017 report by the New York City Comptroller (Stringer 2017) used various estimates of total delays on the New York City subway network and an average wage of US$34/hour to arrive at an annual cost of subway delays of US$ 170 to 389 million (US$ 206 to 470 million in 2022 dollars). This report focused solely on direct productivity loss to individuals due to subway network delays and did not include the bus service.
- Chall (1981) estimated lost personal time on the New York City subway system by adjusting a base wage rate by adding the value of a foregone activity to an "unpleasantness premium" to further differentiate the value of lost time in various activities. They arrive at a total value of US$ 333 million (US$ 1.09 billion in 2022 dollars) annually, which at the time was "close to 40 percent of the size of city income tax revenues".
- A more recent valuation by Dean (2021) involves a welfare analysis of Boston's T subway system that considered a hypothetical reliability improvement of the service from 88% to 94%. In this case a reliability ratio was calculated as the number of riders unaffected by delays divided by the total number of riders, which is more appropriate for headway-based service where late trains can still deliver consistent service to many riders. Their estimate puts the annual welfare losses in the range of US$ 54 to 163 million (US$ 59 to 179 million in 2022 dollars).

These studies focused only on higher-order subway modes in New York City and Boston. They do not consider the extensive and typically less predictable bus network in these cities. It is likely that the overall direct and productivity costs of annual disruption in these cities (and in Toronto) is significantly higher.

6.2 Other Direct and Indirect Costs of Unreliable Service

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[30] In a stated preference survey, respondents are asked to choose among alternatives with varying attributes (such as travel time, cost and/or reliability) within a hypothetical decision context (such as choice of mode for the journey to work.

From a reliability standpoint, transit systems are inherently unstable; without direct intervention via scheduled or real-time control, a transit system will tend to “drift” towards less and less reliable service (Newell 1977) both over the course of a daily operational cycle and more long-term. In addition to the direct impacts of travel times described above, this also has a direct impact on the cost of operations. There is an inherent trade-off between the reliability and speed of a service (Klumpenhouwer and Wirasinghe 2018). Additional padding in the schedule requires more operator hours to provide the same frequency of service on a route, and unreliable end-to-end travel times for vehicles requires adding additional operators to the schedule or spare board to compensate. These additional direct operating costs can be estimated by comparing the required resources under a perfectly reliable service with the existing condition.

There are also indirect costs both to the agency and the rider caused by recurrent and non-recurrent delays. In a Toronto-specific context, research has focussed on the broader operational effects of service disruptions on the subway system on the overall transit network. These effects compound the initial direct delay of a subway disruption as the impacts spread out through the surface network. For example, Diab and Shalaby (2018) found that “subway service interruptions have a statistically significant negative impact on bus and streetcar service operations in terms of slower speeds, with more immediate and intense impacts on streetcar service.” During major disruptions, Diab et al. (2018) found “remarkable fluctuations not only in the utilized number of shuttle service buses over time, but also on the service response and recovery times”. This creates a double-delay issue: The additional travel time by riders and operating costs by the operator, as well as the further erosion of trust in the system due to a widely varying response to disruptions. This suggests that the value of delay and lost productivity experienced by riders goes far beyond the delay itself.

6.3 The Impact of Improved Infrastructure on Reliability

While it may not gather as much public or political attention, taking steps to maintain the state of good repair and to improve existing infrastructure is an important part of maintaining or improving system reliability. Paterson and Vautin (2015) conducted a benefit-cost ratio analysis of transit state of good repair investments in the San Francisco Bay Area and found “regional benefit/cost ratios of close to 3… similar to the benefit/cost ratio of the average transit expansion project”. A significant portion of the positive ratio came from preventing an increase in passenger delays. In other words, investing in existing system improvements is critical to the success of the existing system, and to network expansions that rely on the existing system.

Other existing-system infrastructure improvements can also bring substantial reliability benefits. For example, platform screen doors (PSD) which prevent unauthorized track-level incursions on rail systems have been shown to reduce metro suicides by nearly 90% (Chung et al. 2016; Xing, Lu, and Chen 2019) after their installation. These unfortunate events are not only traumatic to operators and riders who witness them, but they also result in major disruptions (and therefore large economic loss). Other treatments such as dedicated rights of way, passenger crowding and boarding flow management, In general, ensuring a high level of reliability and minimal disruption on a transit service is critical for maintaining transit's positive economic impact. This requires a dedication to both operational and infrastructure improvements and adoption of best practice. The TTC operating and capital budgets fully recognize the need for improved service reliability, as well as safety for transit riders. In 2019, for example 66% of new service added to the system was dedicate to improving service reliability,[31] while, as another important example, the signature Bloor-Yonge Station Capacity Improvement project aims at both increasing passenger safety as well as improving Line 1 operational reliability.[32]

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[31] https://ttc-cdn.azureedge.net/-/media/Project/TTC/DevProto/Documents/Home/About-the-TTC/5_year_plan_10_year_outlook/Attachment-1-TTC_5_year_SP_web_accessible_R3.pdf?rev=69cfa3fbb3034d8a8ca5aaff03bf6a17&hash=9208204C7255C70154C0DFD161BA16F9

[32] https://www.canada.ca/en/office-infrastructure/news/2019/08/backgrounder-getting-torontonians-moving-making-crucial-investments-in-public-transit.html

Chapter 7
Environmental Benefits of Public Transit

Prof. Marianne Hatzopoulou
Professor of Civil and Mineral Engineering
Director, Positive Zero Transport Futures at Mobility Network

7.1 Introduction

Shifting users from private vehicle use to public transit is anticipated to bring a variety of co-benefits ranging from reduced greenhouse gas (GHG) emissions, improved air quality, and better health outcomes (i.e., reduced traffic accidents, reduced exposure to air pollutants, increased physical activity).

This chapter aims to further our understanding of the potential co-benefits of public transit investments in Toronto. Section 7.2 first provides an overview of recent research on the health and climate impacts of public transit in the Greater Toronto and Hamilton Area (GTHA), including the impacts of the TTC's Green Bus program. The case for the environmental benefits of public transit investment is further bolstered in Section 7.2, which summarizes selected case studies of public transit use and system expansion environmental impacts from around the world.

7.2 Climate and Air Quality Benefits of Public Transit in the GTHA

This section summarizes recent environmental impact studies focused on the GTHA. We provide an overview of the GHG impacts of public transit system in the GTHA. Public transit emission intensities are calculated, as well as the emission intensities of other transport modes. The air pollutant emissions associated with bus transit, private vehicles, and commercial fleets are also provided. The section concludes with an illustration of the health and climate benefits associated with bus electrification in the GTHA. All the studies referenced in this section were conducted by Mobility Network's Transportation and Air Quality (TRAQ) research group.

7.2.1 Greenhouse Gas Emissions

Wang et al. (2018) developed a GHG emission inventory for passenger transportation in the GTHA. In their analysis, they estimated that while the public transit system carries 32% of daily passenger kilometers traveled (PKT), it shares only a very minor portion of GHG emissions. Daily GHG emissions associated with household travel in the GTHA were estimated at 30,000 tons of carbon dioxide equivalents (CO_{2eq}) with 96% attributed to private vehicles and 4% to transit. 7.1 illustrates the PKT and emission intensities of private vehicles and public transit. The emission intensity of transit is lower due to higher passenger occupancies.

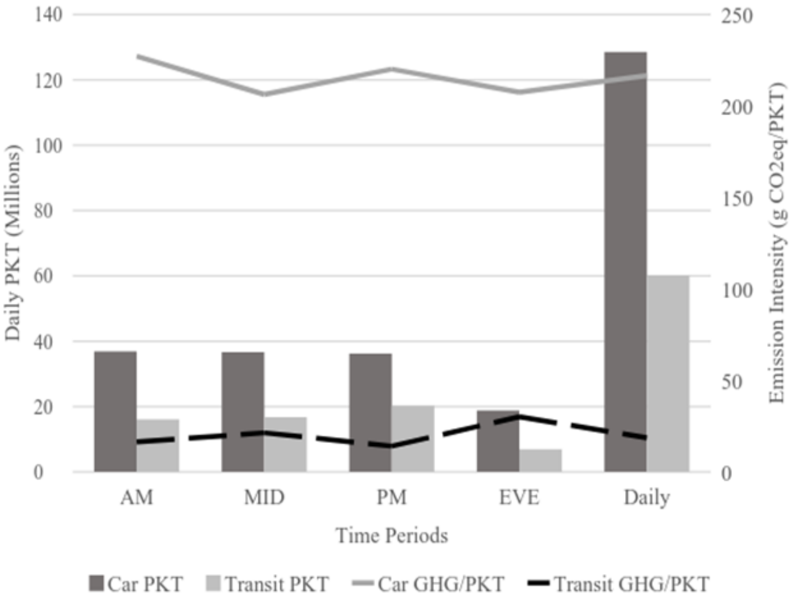
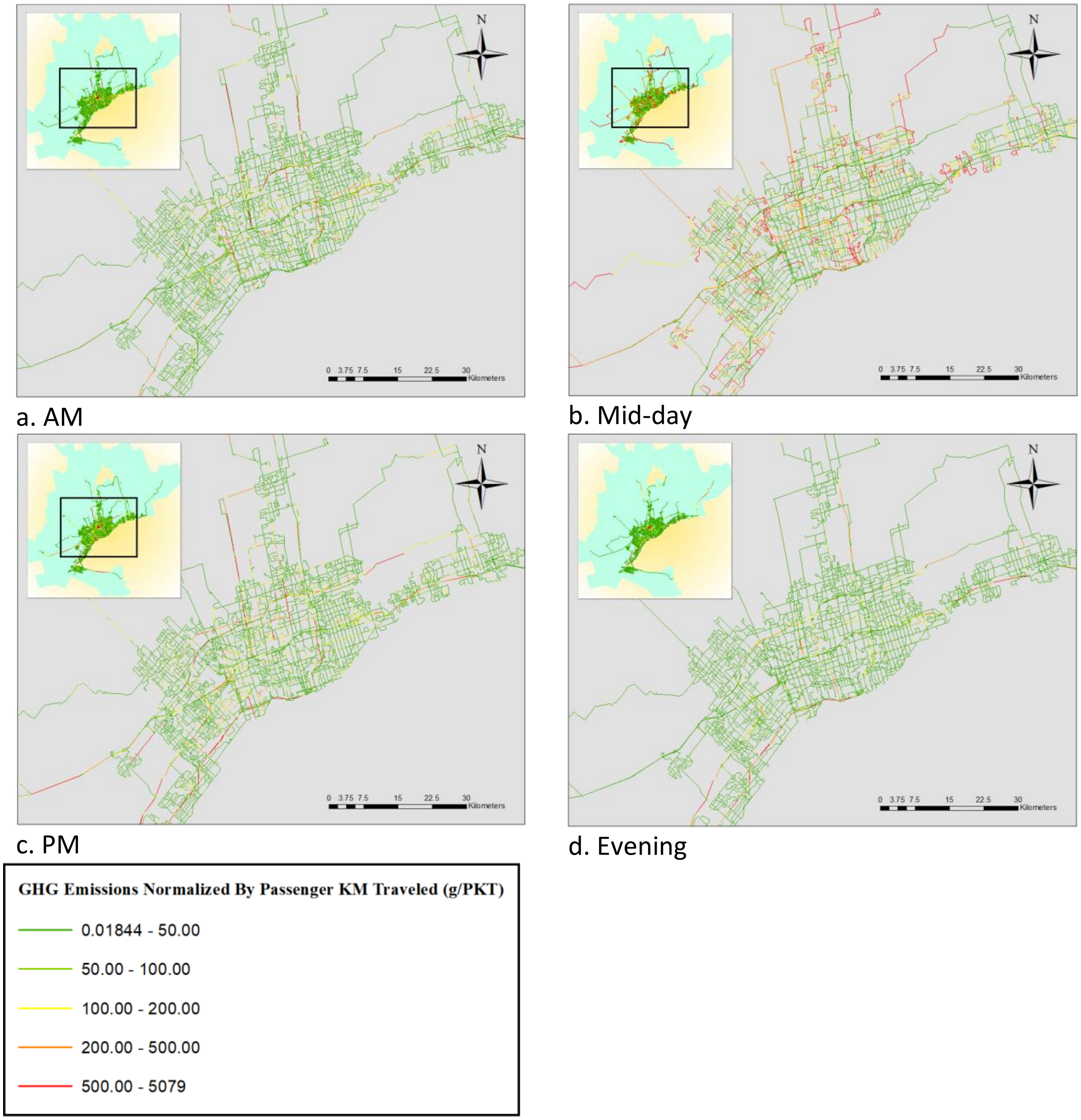


Figure 7.1: Passenger Kilometers Travelled (million PKT) in Private Vehicles and Public Transit and GHG Emission Intensity (g CO_{2eq}/PKT), by time (AM, mid-day, PM, evening). Retrieved from Wang et al. (2018).

Emission intensities for public transit are typically highest on far-end stretches of transit lines and during off-peak hours. Figure 7.2 displays emission intensities for public transit per road link and period of the day (e.g., morning vs evening). Public transit tends to have higher emission intensities in suburban areas and during mid-day, when transit agencies maintain level of service despite lower passenger volumes.



a. AM

b. Mid-day

c. PM

d. Evening

Figure 7.2: Distribution of GHG Emission Intensities (g CO_{2eq}/PKT) for Public Transit across the Network in the a. AM; b. Mid-Day; c. PM; d. Evening. Retrieved from Wang et al. (2018).

On average, the emission intensity of public transit is much lower than that of private vehicles (see Figure 7.3). However, emission intensities for public transit can be higher than those of private vehicles when passenger volume is low. For example, in Figure 7.3, the average emission intensity of transit vehicles exceeds that of private cars in the evening due to low ridership on diesel-fueled buses. Despite this difference, the average emission intensity of all transit modes is around 20 grams (g) CO_{2eq}/PKT compared to 250 gCO_{2eq}/PKT for passenger vehicles.

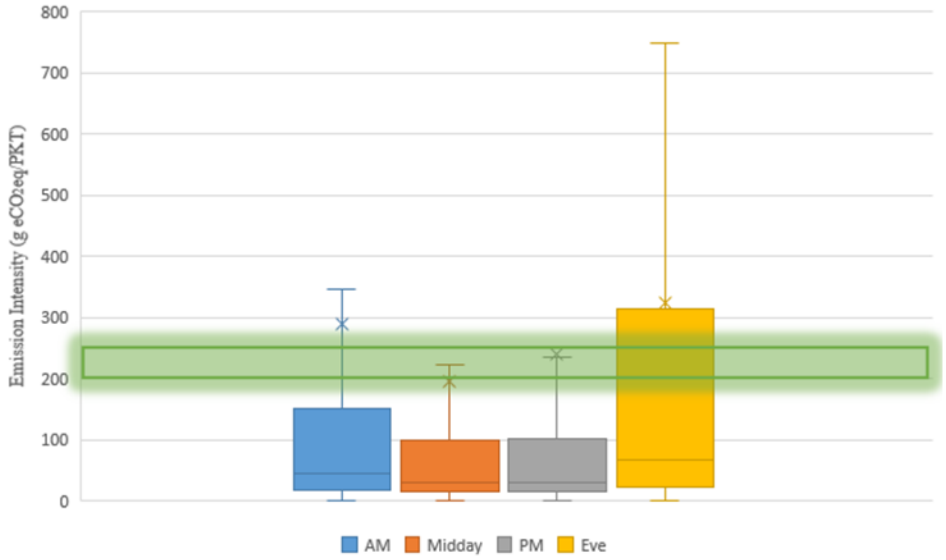


Figure 7.3: Emission Intensity (g CO$_{2eq}$/PKT) for Transit Buses (Crosses indicate average values of emission intensities for buses; the horizontal green bar highlights the 25th- 75th percentiles of private vehicle emission intensities). Retrieved from Wang et al. (2018).

More recently, members of the TRAQ research group analyzed trip-level GHG emissions in the GTHA. Trip-level GHG emissions were estimated based on detailed travel survey data from the Transportation Tomorrow Survey (Malatest, 2018ab). Trip emissions were generated for a representative sample of households across the GTHA, and then the researchers investigated the spatial distribution and disparities across mobility-related GHG emissions. The researchers also calculated the average fuel-cycle GHG emission intensity of all modes in the GTHA. Figure 7.4 displays the real-world GHG emission intensities by mode for trips across the GTHA. The average emission intensity for all trips is 210g CO$_{2eq}$/PKT. Much of the higher emission intensities are generated by private vehicle trips, which have a median emission intensity around 275 g CO$_{2eq}$/PKT. In contrast, public transit trips in the GTHA have comparatively low emission intensities, with median values less than 50 g CO$_{2eq}$/PKT across all public transit modes.

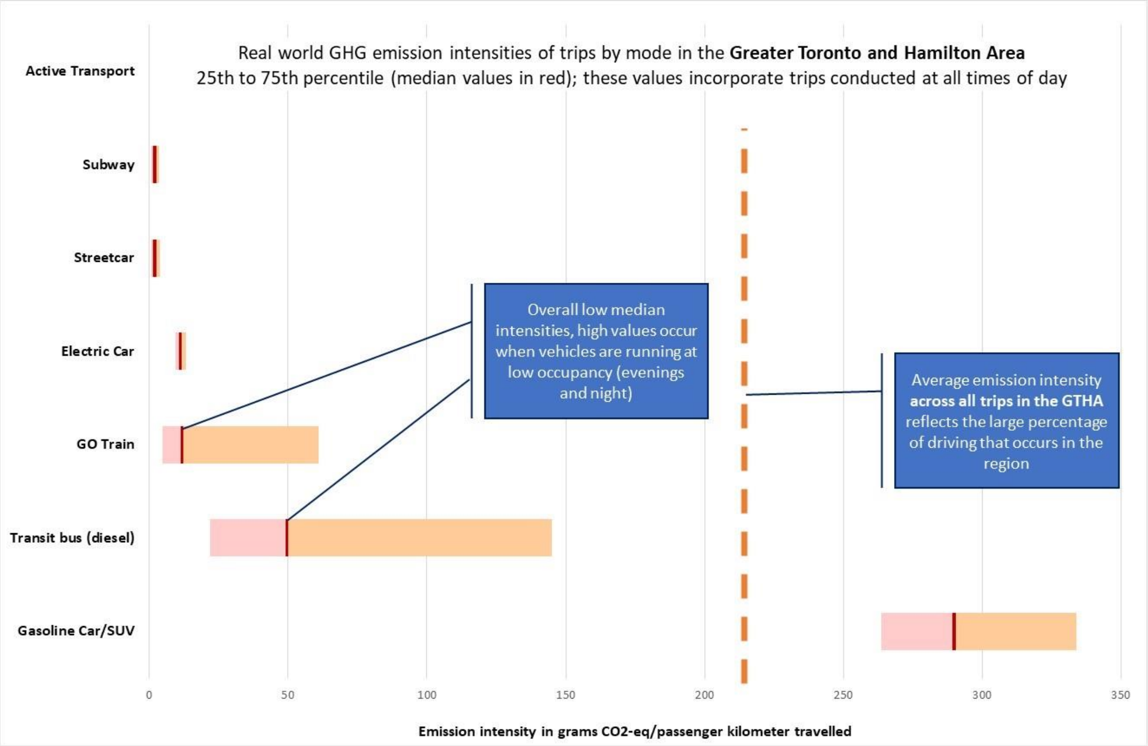
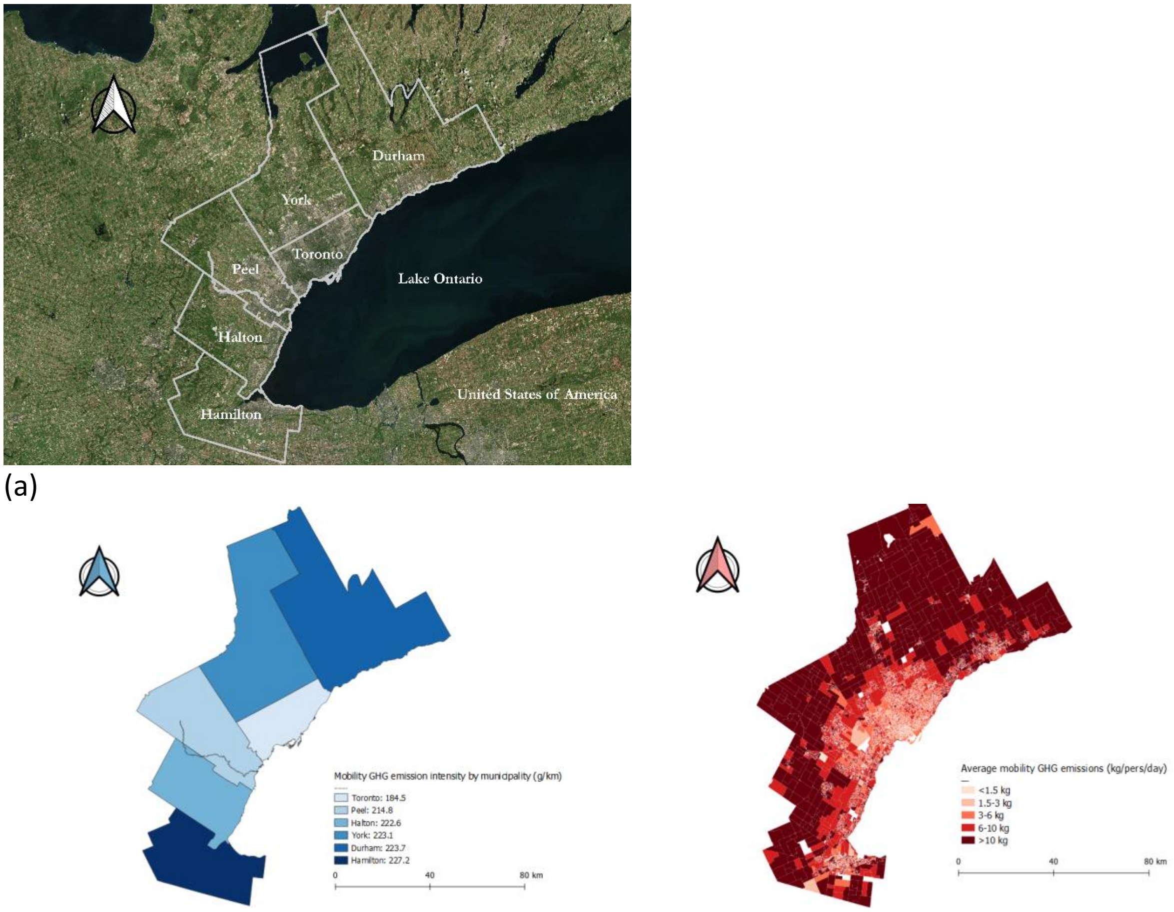


Figure 7.4: Real-world GHG emission intensities of trips by mode in the GTHA. Average intensity across all modes is illustrated by the dashed orange line, while each boxplot shows the 25th to 75th percentile per mode.

The average emission intensity for trips across the GTHA (210 g CO_{2eq}/PKT) is only slightly lower than the emission intensity of a light-duty vehicle circulating at its most energy-efficient speed (60 mile/h or 96 km/h), which is about 236 g/km. This emission intensity reflects the high proportion of driving in the GTHA. The variability in trip emission intensities across the different regional municipalities (Figure 7.5(a)) illustrates the influence of transit and walkability on the personal mobility GHG footprint. For Toronto residents the average trip emission intensity is 184 g CO_{2eq}/PKT, while it is as high as 227 g CO_{2eq}/PKT for residents of the city of Hamilton (Figure 7.5(b)).

Variability across the GTHA is further accentuated when the emission intensity of each trip is weighted by the total number and length of trips per person per day, leading to our estimate of total mobility GHG emissions per person. Figure 7.5(c) illustrates the average mobility GHG emissions per person per day in each Dissemination Area. There is clear spatial variation in daily mobility emissions across the region, where residents of the inner core and the lakeshore region to the south have much lower daily emissions compared to residents of the inner and outer suburbs. The regions close to Lake Ontario have a more compact urban form, which leads to shorter travel distances and better transit accessibility.



(a)

(b) (c)

Figure 7.5: (a) Regional aerial map (b) mobility GHG emission intensity by municipality (g/km), and (c) average mobility GHG emissions by dissemination area (kg/person/day)

7.2.2 Air Pollutant Emissions in the GTHA

Wang et al. (2018) estimated air pollution emitted from passenger transportation in the GTHA. Overall, transit and regional buses carry 26% of daily PKT and they comprise 3% of total nitrogen oxide (NO_x) emissions, 8% of $PM_{2.5}$ emissions (particulate matter with diameters 2.5 micrometers and smaller), and 22% of black carbon (BC) emissions. This means that NO_x and $PM_{2.5}$ emissions are disproportionately lower than the PKT of bus systems, while BC emissions are close to the contribution of PKT. Compared to private vehicles, bus transit offers reduced emissions of NO_x and $PM_{2.5}$. Minet et al. (2021) estimated the burden of private vehicle and bus transit-generated air pollution in the GTHA and identified the potential co-benefits of transit bus electrification. Three scenarios were designed to evaluate the health and climate benefits of three fleets of vehicles in the GTHA:

- Scenario 1 (S1 – 100% electric vehicles (EV)) assumes an electrification of the private passenger vehicle fleet.
- Scenario 2 (S2 – 100% battery electric buses (BEB)) assumes an electrification of the transit bus fleet (among all operators).

- Scenario 3 (S3 – Cleaner Trucks) assumes trucks older than 8 years have recently been renewed.

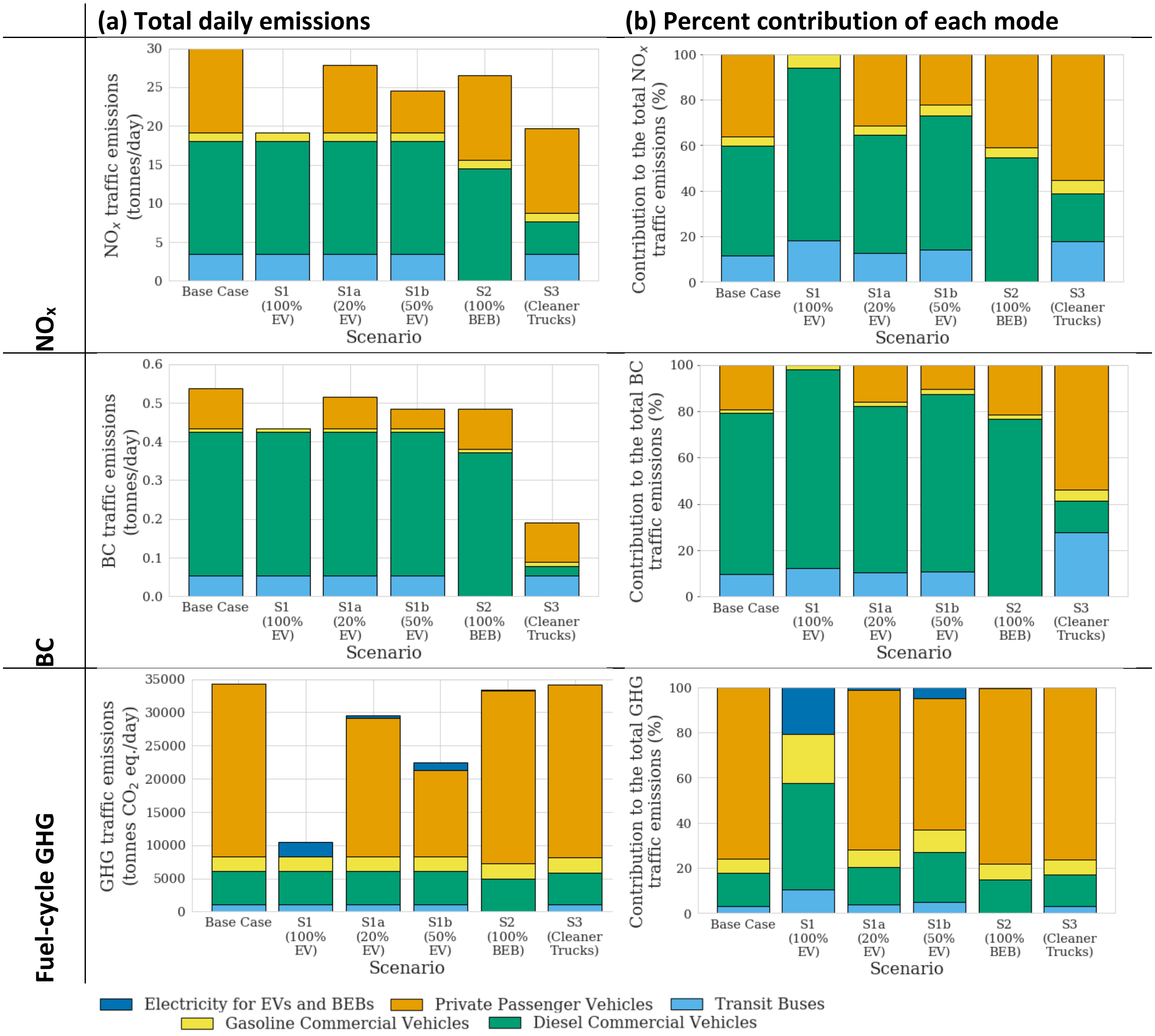


Figure 7.6: Comparison of the NO$_x$, BC and GHG emissions from private passenger vehicles, commercial vehicles, transit buses under the base case and the different scenarios for a typical weekday: (a) total daily emissions; (b) percent contribution of each mode. Retrieved from Minet et al. (2021).

Air pollutant emissions and health outcomes were calculated for the base case and each of the three scenarios. Total daily emissions from traffic amounted to 30.1 tons of NO$_x$, 0.54 tons of BC and about 30,000 tons of CO$_{2eq}$. (Figure7. 6(a)). Under the base case scenario (which represents current emission estimates for the GTHA), transit buses are responsible for approximately 12% of NO$_x$ emissions, 10% of BC emissions, and less than 5% of GHG emissions. The contribution of diesel commercial vehicles and private passenger vehicles to the total NO$_x$

emissions are 52% and 36%, respectively. However, diesel trucks contribute 71% of the BC emissions, and private passenger vehicles contribute 76% of the GHG emissions (Figure 7.6(b)). Bus fleet electrification displays greater benefits for reducing air pollutant emissions than GHG emissions for the GTHA (Figure 7.6(a)).

The spatial distribution of years of life saved by bus electrification (Figure 7.7) illustrates that most of the health benefits are generated in the most populated region, mainly within the city of Toronto. This is likely due to the higher frequency and coverage of the bus transit network, as well as the higher population density in this region.

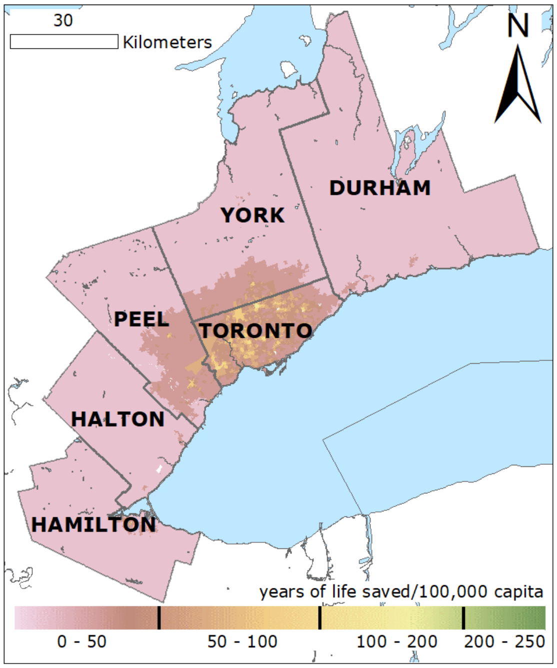


Figure 7.7: Spatial distribution of years of life saved per 100,000 capita under 100% BEB. This figure is based on average numbers of years of life saved extracted from the uncertainty analysis of the health outcome assessment. Retrieved from Minet et al. (2021).

Next, Minet et al. (2021) calculated the premature mortality associated with air pollution generated by the different modes. Figure 7.8(a) displays the annual years of life lost (YLL) attributed to transit buses, private passenger vehicles, and commercial vehicles and Figure 7.8(b) displays the annual premature deaths attributed to these modes. Diesel transit buses have the smallest impact and electrifying transit buses would carry health benefits.

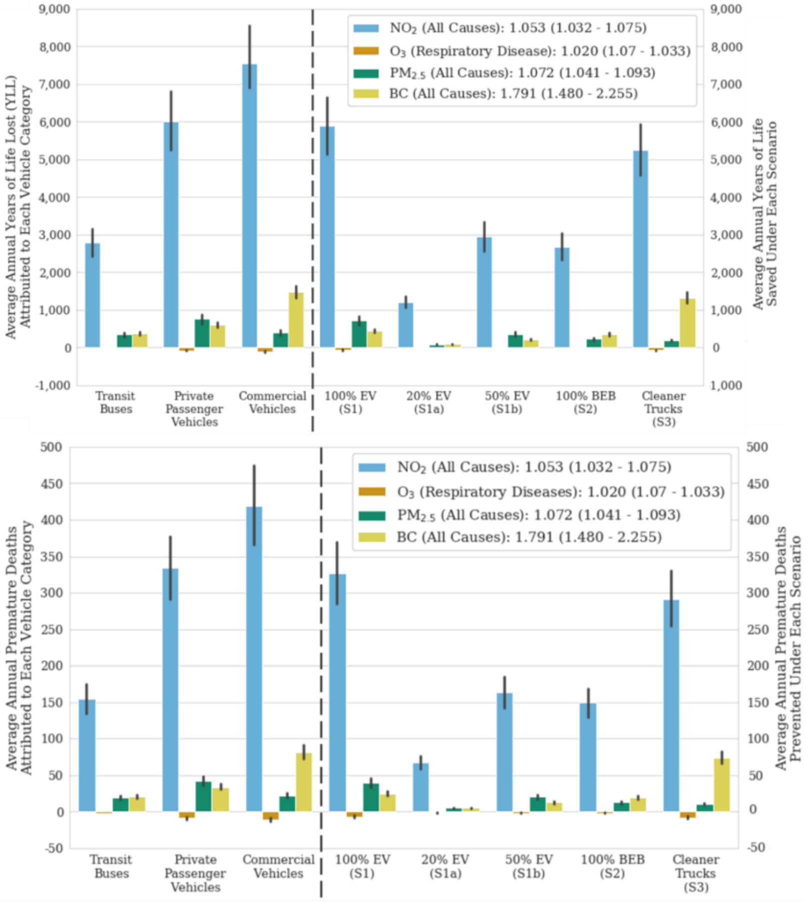


Figure 7.8: Comparison of the annual health outcomes associated with each vehicle category and each scenario (each outcome related to the three vehicle categories indicates a burden, while the outcomes related to the scenarios indicate benefits). The uncertainty bars represent the interquartile range resulting from the use of a range of odds ratios (ORs) associated with each pollutant and health outcome (indicated in parentheses in the legend). Retrieved from Minet et al. (2021).

7.2.3 TTC Green Bus Program

The TTC is in the midst of a program to convert its entire bus fleet (including Wheel Trans) to zero emissions by 2040 (TTC, 2020, 2022). Continuing investment in this program is essential to the City of Toronto achieving its TransformTO climate change targets as well as to continue to reduce TTC bus emissions of health-related emissions such as nitrogen oxides and particulate matter.

Every bus converted from conventional “clean” diesel to an electric bus (eBus) results in a 100% reduction in vehicle GHG emissions (93 tonnes/bus/year)[33] and an estimated fuel/energy cost saving of 77% ($40,000/bus/year).[34] Further, to the extent that the TTC is able to attract new

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[33] TTC (2022). Note that this assumes that the electricity used to power the bus is carbon-free. While Ontario’s electricity grid is quite “green”, it is not 100% carbon-free.

[34] TTC (2022). This value depends upon the price of both electricity and diesel fuel, both of which can be expected to increase in the future.

riders that are diverted from cars, as discussed above, there are additional environmental and health benefits in terms of GHG and air pollution reductions from the foregone car trips. For more in-depth analysis of the environmental and economic impacts of the Green Bus program, see TTC (2022).

7.3 Global Evidence of Public Transit Climate, Air Quality, and Health Benefits

The following subsections outline case studies from around the world that investigate the benefits of opening and expanding modes of public transit. These studies cover an array of transit modes including bus transit, bus rapid transit (BRT), light rail transit (LRT), and metro rail. The review also includes case studies examining the impact of bus electrification on air quality and GHG emissions.

7.3.1 Climate Benefits of Public Transit Electrification

In Singapore, researchers compared the life-cycle costs and GHG emissions of 12meter human-driven diesel buses and electric, automated 6meter minibuses. Although a larger number of vehicles were needed to provide the same level of service with the electric minibuses, the researchers found that they led to a 43% reduction in total life cycle costs and a 47% reduction in life cycle GHG emissions (Pathak et al., 2021).

Kotz et al. (2020) examined the CO_2 emissions associated with existing diesel bus operations in two cities in Mexico: Mexico City and León. The researchers wanted to identify whether bus operations in each city would be good candidates for electrification based on real-world performance data. They found that bus electrification in Mexico City had the highest emissions benefit, resulting in almost 75% less CO_2 emissions. In comparison, bus electrification in León led to 45 to 55% reductions in CO_2 emissions. The differences in benefits are mainly due to operational characteristics – the Mexico City buses had lower average moving speed and daily distance, with over seven hours of idling on average per day. While bus electrification led to emission reductions for both cities, these findings demonstrate the need to prioritize certain routes with high ridership and congestion for electrification.

7.3.2 Air Quality Benefits of Public Transit

Chen and Whalley (2012) examined the air quality effects of a new rail system in Taiwan. The researchers applied a regression discontinuity approach to the level of transit utilization. They found that the system's opening reduced carbon monoxide (CO) by 5-15% but had little effect on ground level ozone (O_3) pollution. Lalive et al. (2013) examined the relationship between rail service and air quality in Germany over a 10-year period. The authors found that increases in rail service frequency led to a reduction in some pollutants (nitric oxide (NO), nitrogen dioxide (NO_2) and CO). To understand the impact of metro transit on air quality, Li et al. (2022) examined air quality data six weeks before and after the opening dates of metro transit in 26 cities throughout China. Overall, the researchers found that the opening of metro transit improved air quality. $PM_{2.5}$ and NO_2 were significantly reduced by 20.3% and 12.9%, respectively. PM_{10} (particulate matter with diameters 10 micrometers and smaller) also decreased by 2.2%, but this result was not statistically significant. The researchers believe the improvements in air quality are likely due to a substitution effect (e.g., travellers switching from private vehicles to public transit).

At least one study examined the impact of BRT. Bel and Holst (2018) analysed air pollutant concentrations before and after the introduction of a BRT system in Mexico City. Using a differences-in-differences approach, the researchers found significant reductions in the concentrations of all pollutants except for sulphur dioxide (SO_2). Specifically, CO concentrations were reduced by between 5.5 and 7.2%, NO_X by between 4.7 and 6.5%, and PM_{10} by between 7.3 and 9.2%, depending on the city area. However, the researchers note that further studies are needed to understand the long-term effect of the project (e.g., whether road congestion was temporarily reduced or whether behavioural changes endure).

Holland et al. (2021) performed an expansive analysis of the environmental benefits (including a consideration of both air pollution and greenhouse gas emissions) of bus electrification across all counties in the contiguous U.S. The researchers sought to understand the relative environmental benefits of electric buses compared to diesel- and compressed natural gas (CNG)-powered buses. The researchers found that on average, the benefits from reducing air pollution are positive across all counties. The benefits are largest in certain metropolitan areas, totalling $65M per year in Los Angeles and more than $10M per year in six other metropolitan areas. They also calculated the net present value (NPV) comparison of the new electric buses to diesel and CNG buses. The NPV comparison included capital costs, operations and maintenance expenditures, and external costs due to air pollution damages. The researchers found that relative to diesel, the NPV benefit of bus electrification is positive in two-thirds of urban counties. However, relative to CNG, the NPV benefit is negative in all counties. Overall, the study illustrates the importance of considering existing fleet and operational characteristics to determine the best candidates for electrification.

7.3.3 Health Benefits of Public Transit

Park and Sener (2019) evaluate the effect of the opening of the LRT in Houston, Texas on the number of daily deaths due to stroke for those residing in the surrounding area. The researchers used an interrupted time-series analysis, comparing those living in the area before and after the opening of the LRT. The researchers used a distant monitoring site as a control group for traffic-related pollution. They found daily stroke mortality was reduced by more than 30% after the opening of LRT for those living in the surrounding area, while there was either an increase or a considerably smaller reduction (less than 10%) for the control groups.

Tétreault et al. (2018) investigated the health benefits and burdens of a business-as-usual (BAU) scenario and public transit (PT) scenario in 2031, in which 8 new subway and 19 new train stations were installed within the Montreal region. The researchers estimated the health effects associated with air pollution, road trauma, and physical activity levels. The planned increase in public transit infrastructure is anticipated to reduce the overall burden of transportation by 2.5 Disability Adjusted Life Years (DALYs) per 100,000 persons. The decrease is mainly attributed to reduction in road traumas as well as gains in active transportation use.

The researchers note that the impact of planned transport infrastructure was very low and localized to the areas where the new stations were planned, and thus planned public transport projects were unlikely to dramatically reduce the burden of disease attributed to road vehicles and infrastructure in the Montreal region.

MacDonald et al. (2010) assessed the effect of LRT use on body mass index (BMI), obesity and weekly recommended physical activity (RPA) levels. The researchers collected data on individuals, both LRT and non-LRT users, for several months before and after the completion of the LRT system in Charlotte, North Carolina. They found significant association between LRT use and reductions in BMI over time. The LRT users reduced their BMI by an average of 1.18 kg/m^2 compared to similarly situated non-LRT users over a 12- to 18-month follow-up period. Similarly, the researchers found that LRT users were 81% less likely to become obese over time. However, there was no significant relationship between LRT use and meeting weekly RPA levels of walking.

Brown and Werner (2008) assessed travel behaviour and obesity among continued LRT users, new LRT users, and non-users in a Salt Lake City neighbourhood. Study participants wore accelerometers to examine their physical activity and completed surveys before and after the opening of a new light rail stop in their neighbourhood. The researchers found that obesity rates were higher among the non-users (65%) compared to new users (26%) and continued users (15%). The researchers also found that LRT users have more healthy walking bouts (defined as moderate-intensity activity lasting at least 8 minutes). However, use of LRT may be limited by physical barriers to use, particularly for residents with obesity or those who are sensitive to walking distance.

Chapter 8
Social, Health and Community Benefits of Public Transit

Dr. Matthew Palm
Research Associate, Mobilizing Justice, University of Toronto Scarborough
Dr. Ignacio Tiznado Aitken
Postdoctoral Fellow, Mobility Network, University of Toronto Scarborough

8.1 Introduction

The links between transportation and wellbeing are well documented in the literature. Safe housing, transportation, access to opportunities and physical activity are just a few of the social determinants of health (NEJM Catalyst, 2017) which can have a major impact on people's quality of life. Our transport systems create positive pathways to social connectivity, physical activity, access, and independence, particularly for vulnerable populations such as the elderly and children.

One of the most relevant roles of public transport is ensuring equity "by providing a low-cost, cross-town means of travel for people who cannot or will not drive" (Palm et al., 2022, p. 15). The challenge of public transport worldwide is creating a high-quality and affordable system that fulfils the needs of the most disadvantaged population groups, particularly for those who live in less dense and connected areas, promoting social inclusion and activity participation. Despite the generally equitable performance of the public transport system in Toronto (Foth et al., 2013), the suburbanization of poverty in the region has evidenced increased barriers for daily travel and activity participation, with over 600,000 people living in areas with inadequate transit accessibility (Allen & Farber, 2019). Therefore, sustaining and continuously improving public transport systems in countries such as Canada that rely heavily on cars is essential to move towards transport equity.

In the following sections we present several key dimensions where public transport performs an important role in people's daily lives: enhancing social capital and sense of community, affecting subjective wellbeing, transit-oriented development to boost ridership, and engaging in several key daily activities as jobs, education, food, and healthcare.

8.2 Public Transport and Subjective Wellbeing

Several links can be drawn between subjective wellbeing and transportation. Mobility experiences shape positive or negative feelings when traveling, the ability to reach and participate (or not) in different activities, and being socially included or excluded (De Vos et al., 2013). Experiencing safe, frequent and reliable public transport will allow people to positively evaluate their travel experiences and access the activities they need in daily life, and therefore, enhancing a positive relationship with subjective wellbeing (Cao, 2013; Ettema et al., 2010).

A literature review on travel and subjective wellbeing shows that there has been considerable attention for possible differences between car and public transport users (De Vos et al., 2013). Mixed evidence can be found. While some studies found that car users have a higher satisfaction (Ettema et al., 2011), Abou-Zeid showed that public transport usually allows travel time use for engaging in other activities compared to car users, who usually experience more stress and anxiety (Abou-Zeid et al., 2012). Similarly, encounters with other passengers when using public transport have a positive effect on satisfaction and wellbeing (Ettema et al., 2012).

8.3 Public Transport and Social Capital

Social capital (SC) describes the advantage that individuals and communities can gain from social participation, mutual assistance and trust (Currie & Stanley, 2008; Schwanen et al., 2015). It usually refers to the development of (i) reciprocity (the process of exchanging goods/services in a social relationship), (ii) social networks or participation and (iii) trust between people (Putnam, 1993).

Understanding the link between transportation and SC is important, as disadvantaged groups can lack personal mobility and accessibility. Public transport can provide mobility for this group and in doing so provide a greater opportunity to create social networks, trust and reciprocity. Public transport by definition involves travelling with others and hence provides opportunities for social interaction. It is likely that this represents the most significant opportunity for urban interaction with groups outside immediate social contexts (Currie & Stanley, 2008). Public transport is a major element of the urban planning concept of the 'liveable city', enhancing positive social interactions. For example, Castel & Farber found that, overall, when transit availability and service are better, more people get to know their neighbours and do favours for them (Castel & Farber, 2017). This is particularly true for those living in streetcar and subway proximity, which positively influences knowing one's neighbours.

Recent research by the authors has shown that increasing trip making and improving a person's social capital and sense of community is likely to reduce risks of social exclusion (Stanley et al., 2012), contributing to personal wellbeing. Connections between social exclusion, transport disadvantage and social capital include (Schwanen et al., 2015):

- Access to transport resources, know-how and autonomy can have effects on the multidimensional support that persons can obtain or give to their social networks.
- Knowledge and skills about transport and activities can impact the learning processes within social networks, key to overcome or perpetuate transport disadvantage and social capital levels.
- Exposure to transport negative externalities may affect health and well-being, which can affect participation in society and social capital extension.
- Level of trust in transport systems can affect use, knowledge, skills, and participation in decision-making.
- Level of trust and reciprocity of communities may influence the emergence of grassroots initiatives and participation in decision-making.

8.4 Transit-oriented Development and New Development Around Transit

Transit oriented development (TOD) has emerged as a goal to reduce motorized trips, especially those who drive alone (Ibraeva et al., 2020). Cities such as Copenhagen, Stockholm, Singapore, Tokyo and Curitiba are some of the precursors of TOD, promoting compact and mixed-used areas designed for transit connectivity. TOD is different from any area around a transit station without proper connections to transit (transit adjacent development, TAD) (Renne, 2009), enhancing pedestrian amenities, lower parking supply, and physical designs that are thought to encourage households to walk, bicycle, and take transit instead of driving (Chatman, 2013).

The evidence has been very consistent over the years. Residents of TOD neighbourhoods commute 1.4-5.1% more by public transport (Cervero & Gorham, 1995), and the share of public transport for those living within 800m buffer is 27% compared to 7% of those living within 800m and 4.8 km (Cervero, 2007). Despite not all TOD implementations showing the same results, in the Toronto region stations with higher densities, walkable conditions and mixed land uses "were associated with higher rates of transit, walking, and cycling, lower household VKT" (Higgins & Kanaroglou, 2016).

Moreover, public transport systems can play a large role in attracting new developments that are able to change the urban form. TOD has the potential to be a strategy for sustainable urban growth (Ibraeva et al., 2020), either densifying land-use in rail-served areas or by improving transit supply in high-density areas, improving accessibility conditions in a specific area (Papa & Bertolini, 2015).

8.5 Transit and Justice for Equity Seeking Populations

The City of Toronto currently seeks to "apply an equity lens to its activities to identify and remove barriers and to support best practices in planning, budgeting, implementation and evaluation of its programs and services" (City of Toronto, 2022). Public transit plays and essential role in equitable access to programs, services, and opportunities. While the following Section 8.6 discusses this role in the broadest possible way, this section lays out the specific value transit brings to help the city advance equity along the lines of gender, disability, and immigration.

8.5.1 *Gender Equity and Transit*

As discussed in Section 8.4, transit mode share for all trip purposes is consistently higher for women than for men in the Greater Toronto Hamilton Area (Colley, 2017). This is also true in the case of commuting mode shares in Toronto specifically, where 44% of women used public transit to get to work compared to just 30% of men in 2016 (Statistics Canada, 2021). These differences mirror women's underrepresentation in driving and active travel modes, which could reflect households privileging men's travel for automobile use (Palm, Allen, et al., 2021), as well as gendered safety concerns about active travel (Mitra & Nash, 2019). At the same time, transit's traditional peak-hour orientation makes its service less beneficial for a myriad of off-peak trip purposes that women are more likely to do, such as household care work and chaperoning children (Babbar et al., 2022), travel often referred to as "mobility of care" (Sánchez-de Madariaga & Zucchini, 2020). As such, it is possible that with more investment in off-peak service, transit could provide even greater benefits to women in Canadian society. Regardless, the fact that women are more likely to use transit than men is indicative of the importance of the mode in advancing gender equity in our cities.

8.5.2 *Transit and the Needs of People with Disabilities*

Public transit is essential to the welfare of many people with disabilities, and Toronto is no exception in this regard. One U.S. study sought to measure the benefit-cost ratio on paratransit services, and found it almost incalculably high due to a total absence of feasible alternatives for many essential trips (Nguyen-Hoang & Yeung, 2010). This importance is reflected in the repercussions of the COVID-19 pandemic's impact on paratransit services. Changes to, and lack of, paratransit services led to deferred medical care and increased food insecurity among some paratransit users (Assi et al., 2022; Koon et al., 2022; Palm, Sturrock, et al., 2021; Wang et al., 2022). The deep reliance of users on these services makes them a critical component to delivering an equitable society for people with disabilities. Recent evidence in Toronto, Canada investigates how people with disabilities (PWD) use accessible taxis, showing that the primary trip purpose of PWD is home-based health-related service, with heterogeneous waiting and in-vehicle times depending on temporal aspects of trips (i.e., departure time, day of the week, and season) and neighbourhood-level factors (i.e., average income, unemployment rate, and rate of visible minorities) (Zhang et al., under review).

In the case of the TTC, "all buses, regardless of the propulsion technology, will be compliant with the Canadian Standards Association D435 standard for accessible transit buses, which outlines requirements for safe transportation for persons with physical disabilities. All buses will also be compliant with the Accessibility for Ontarians with Disabilities Act, 2005 (AODA). The TTC strives to exceed the associated requirements outlined and has included the Advisory Committee on Accessible Transit (ACAT) in design reviews of its bus procurements." (TTC, 2022). In addition, the 2022-2031 Capital Budget and Plan provides full funding of $621 million to complete the TTC's Easier Access Program, which is underway to make all subway stations accessible by 2025 with elevators, wide fare-gates and automatic sliding doors.[35]

8.5.3 *Transit and Immigration*

Public transit plays a critical role in Toronto's ability to welcome newcomers from around the world. Newcomers are significantly more likely to use transit to commute to work compared to Canadian-born residents in the GTA (Harun et al., 2021; Lo et al., 2010). Immigration is also growing in the GTA's suburbs. But even in these locations where transit service may be lower, newcomers are still more likely to depend on the mode to reach work (Allen et al., 2021). Transportation is also a major barrier to newcomers' access to healthcare (McKeary & Newbold, 2010) and social support (Farber et al., 2018). Fallout from the COVID-19 pandemic highlighted these dynamics, as newcomers who avoided public transit were more likely to defer healthcare (Palm, Sturrock, et al., 2021), and were less likely to feel that they could avoid transit for an extended period of time (Palm, Allen, et al., 2021). The federal government aims to settle over a million new people in Canada within the next three years (Government of Canada, 2022), making continued investment in public transit critical for the region's future.

8.6 Transit, Activity Participation, and Life Outcomes

A growing body of research argues that public transit accessibility has a significant and positive impact on activity participation (Allen & Farber, 2020; Luz et al., 2022; Tao et al., 2022), with the latter usually measured as the number of trips taken by travel survey respondents using any mode. One study from Brazil relies on an instrumental variable research design to argue for a *causal* relationship. They find that travellers with the highest level of transit accessibility in their study region conduct between 1.48 to 2.06 times as many activities as the travellers with the lowest level of transit accessibility (Luz et al., 2022). In short, those with more transit access do more.

Research on this relationship from Toronto is cross-sectional, but still provides powerful evidence that transit plays an outsized role in the ability of GTA residents on low incomes to participate fully in society. Allen & Farber (2020) analysed the relationship between transit accessibility and the number of out-of-home activities reached in the GTA using the Transportation Tomorrow Survey. While they did not find a strong relationship among the general population, they found transit access strongly and positively predicts the number of activities conducted per day for individuals in zero-car households, especially those that are also on low incomes. These associations are replotted in Figure 8.1 below.

Among zero-car households with incomes below $60,000 per year, Allen and Farber specify a sigmoidal relationship between transit access and activity participation: large increases in transit access precipitate large increases in activity participation for these households. Unsurprisingly then, a growing literature identifies positive impacts of transit on a wide range of

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[35] https://www.toronto.ca/legdocs/mmis/2022/ex/bgrd/backgroundfile-199568.pdf

out-of-home activities. These include job-search related activities, voting, utilization of healthcare, educational activities, and food-related trip making. The remainder of this chapter synthesizes those findings.

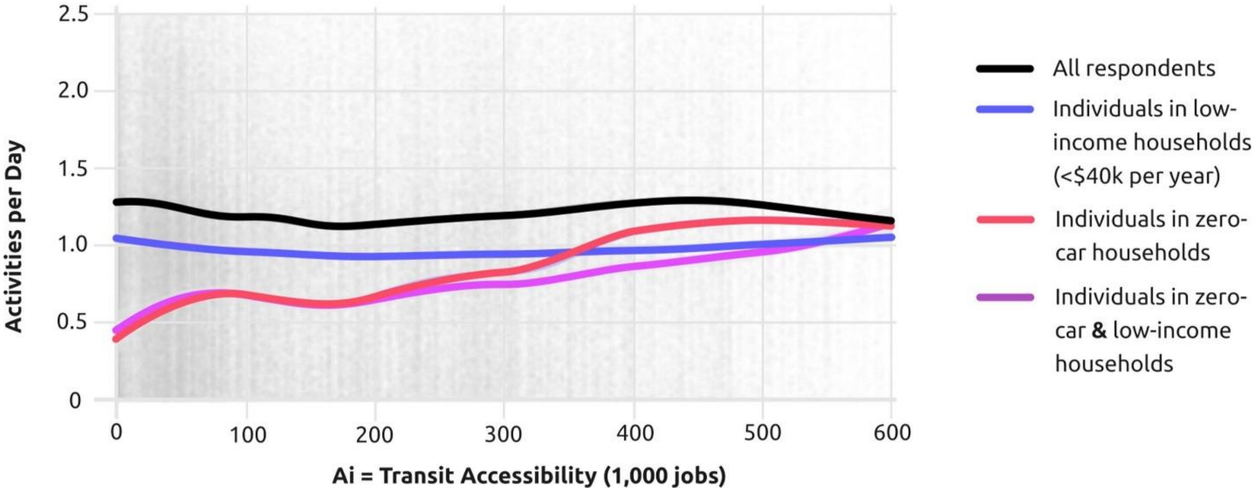

Figure 8.1: The relationship between transit accessibility and activities completed by residents in the GTA, from Allen and Farber (2021)

8.6.1 Equitable Employment Outcomes and Access

A recent systematic review finds evidence that “the opening of new public transport infrastructure and subsidies facilitate job search and, hence, increase employment probabilities” (Bastiaanssen et al., 2020, p. 616). Specifically, $50 towards free fares for job seekers in Washington D.C. increased the likelihood of an individual gaining employment within the first 40 days by 9% (Phillips, 2014). A Light Rail Transit (LRT) line opening in Salt Lake City increased employment by 12-8% (not percentage points) relative to control group neighbourhoods in a study that controlled for LRT-selection using instrumental variable regression. A study looking at the inverse, or what happens to employment when rail lines go down, in this case in New York City after hurricane Sandy, found that living in close proximity to the R train in 2013 was associated with a 1.4% reduction in the likelihood of being employed (Tyndall, 2017).

While experimental evidence is not available for Toronto, cross-sectional research suggests the TTC plays a prominent role in providing access to employment for households with low incomes. In the GTA, the elasticity of demand for transit with respect to accessibility is highest for low-income car-owners (Yousefzadeh Barri et al., 2021). These findings are reprinted in Figure 8.2., which shows that as the number of cars per household driver increases, so too does the household’s elasticity of transit demand. However, this change is greater for households on low incomes. As such, transit service improvements targeting communities with significant low-income car-owning populations may yield the highest ridership gains. Regardless of the policy implications, these dynamics highlight the essential role transit plays for low-income households, including low-income households with vehicles. The TTC service plan, for example, will enhance transit service to Neighbourhood Improvement Areas by improving access to employment opportunities by 14%.[36]

	<40k	40k-60k	60k-100k	100k-125k	>125k
VA=1+	0.85	0.85	0.71	0.74	0.64
0.5<VA<1	1.02	0.62	0.66	0.52	0.57
VA=0.5	0.59	0.62	0.57	0.59	0.65
0<VA <0.5	0.48	0.54	0.54	0.56	0.40
VA=0	0.17	0.16	0.13§	0.08§	0.22§

Figure 8.2: Elasticities of demand for transit by income and number of vehicles per household driver, from Yousefzadeh Barri et al. (2021)

8.6.2 Healthcare Utilization and Missed Doctor's Visits

Another systematic review assessed the importance of public transit for healthcare access, and found strong evidence across the literature that transportation is a significant barrier to healthcare access among several populations, including children, immigrants, older adults, and people with chronic health conditions (Syed et al., 2013). One study looked at the impact of the U.S. federal government restricting the use of Medicaid dollars on transportation services, finding it was associated with 16% decline in primary care visits, a 7% increase in visits to neighbourhood clinics, and an 8% reduction in emergency room visits (Tierney et al., 2000). A more recent study on the impact of a light rail line on missed appointments at nearby medical

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[36] : https://ttc-cdn.azureedge.net/-/media/Project/TTC/DevProto/Documents/Home/About-the-TTC/5_year_plan_10_year_outlook/Attachment-1-TTC_5_year_SP_web_accessible_R3.pdf?rev=69cfa3fbb3034d8a8ca5aaff03bf6a17&hash=9208204C7255C70154C0DFD161BA16F9

facilities found that the line reduced no-shows by 0.5 percentage points, or 4.5% relative to the baseline period. This effect was higher among Medicare recipients (people on low incomes) at 1.6 percentage points or 9.5% relative to the baseline (Smith et al., 2022).

8.6.3 Schools and Educational Activity Participation

Toronto- and Canadian- based evidence on the benefits of public transit on education activity participation is strong. Among Torontonian high school students attending their local TDSB school, 15% use public transit (59% walk), while 33% of those commuting to the nearest TCDSB school use public transit (36% walk). In contrast, 51% of students attending a non-local school of any kind (through Optional Attendance, or to attend a school that attracts city-wide) use public transit as their school mode (Palm & Farber, 2020). This study found that every 100,000 unit increase in the number of jobs reachable by transit from a students' home increases their likelihood of participating in any kind of after-school activity by 1%. They also note that this same increase corresponds to a 2% greater likelihood of a student attending a non-local school (Palm & Farber, 2020).

For university students, the evidence is also strong. About a third of university students in the Greater Golden Horseshoe believe that commuting to school is a barrier to academic success, with 48% saying they have picked courses they take based on commute considerations, according to the StudentMOVETO survey (Taylor & Mitra, 2021). This study reports that 46% of university students in the region take local public transit to university, while another 13% rely on regional transit (Taylor & Mitra, 2021). A similar study found that university students using transit are significantly more likely to commute three or fewer days a week to campus (compared to people who walk to campus) but are 10% less likely to commute four days a week and 5.8% less likely to commute five days a week. The same study notes that transit student commuters are 1.6 times more likely to report that transportation barriers inhibit their participation in on-campus activities. Unfortunately, none of these studies associate transit service levels with these outcomes, but given the broader evidence that transit access increases activity participation among transit users (Allen & Farber, 2020), this impact is likely and should be investigated further.

8.6.4 Voting

Transit access may play a significant role in predicting voter turnout in Ontario, though there is only one peer-reviewed study on this topic. In a study on voter turnout and transit access to voting stations in the 2015 general election, political scientists found a significant U-shaped relationship between transit travel times to the nearest polling station at noon (Garnett & Grogan, 2021). Specifically, their model showed turnout declining as travel times increase until a travel time of about 22 minutes, after which point turnout increases. Notably, their model controls for walking and driving time, as well as distance. Similar research in the United States finds transit can even be associated with turnout in a city where the transit mode share is much smaller, such as Atlanta (Rowangould et al., 2022)

8.6.5 Groceries and Food

People on low-incomes are significantly more likely to rely on public transit to access grocery stores, particularly grocery stores outside of their neighbourhoods (Cannuscio et al., 2013; Shannon & Christian, 2017).

Evidence on the impacts of food access on health are more limited. One study suggests that the neighbourhood share of zero-car households is associated with higher obesity levels among the food insecure as reported in administrative data covering those same neighbourhoods (Christian, 2010). Canadian research suggests that young people in denser, more amenity and transit rich environments eat fast food less frequently (Liu et al., 2020).

The COVID-19 pandemic revealed the depth of transit's importance for grocery access in Toronto. A survey of riders continuing to use transit found that 80% rated groceries and pharmacies as the most important destinations they reached by transit in May 2020, six weeks into the city's first lockdown (Palm et al., 2020). Among the majority who gave up riding transit to avoid exposure to COVID-19 during this period, 9% reported that giving up transit made it 'much more' difficult to get groceries, with women and people with disabilities overrepresented in this group (Palm, Allen, et al., 2021). However, further research is needed to understand the role of transit in expanding food access and enhancing residents' food environments (Widener, 2018).

Chapter 9

Discussion of Findings

Prof. Eric J. Miller
Professor, Department of Civil and Mineral Engineering
Director, Mobility Network at the University of Toronto School of Cities

This paper presents an extended discussion of the economic, social and environmental benefits of transit investment, based on the authors' research, the international literature and the Toronto experience and context.

The fundamental message of this paper is that public transit (in the case of the city of Toronto, the TTC) is an integral, fundamental component of not just the city's infrastructure but of the life and functioning of the city itself. The city of Toronto as we know it, and our ambitions for what it might yet become, would not exist without the extensive, high quality transit system which is the TTC. As discussed in Chapter 5 of this paper, as a very basic practical matter, if the TTC did not exist, the city of Toronto would grind to a halt: we simply could not move the millions of people who travel into, out of and within Toronto on a daily basis. We could not build enough roads to replace the TTC (even if this meant environmental or economic sense, which it does not); we could not keep the strong and vibrant city core that is our signature and which we cherish; and we could not get suburban workers to their jobs and their families to stores and services. Further, drivers benefit as much as transit riders from investing in transit: every person on the TTC is one less driver generating congestion on the city's roads for those who must use their car to travel.

Cities exist for many reasons, but at their core they are economic engines. Without an efficient, effective transit system, this engine cannot run smoothly, let alone thrive. This study documents the economic benefits of public transit, including a new macroeconomic analysis, presented in Chapter 3, that dives much more deeply into this question through the use of a formal macroeconomic model of the Canadian economy to quantify the impacts of investment in the TTC. The TTC is an economic enterprise that is a significant component of not just

Toronto's but Ontario's economy, and, as demonstrated in this study's analysis, generates significant national, provincial and local benefits in terms of economic growth and job creation.

The total economic benefits of a transit system such as TTC, however, are actually very difficult to isolate, since transit is so embedded in everything we do. And so, the somewhat more qualitative story that we have woven in Chapters 2 and 4 of this paper hopefully complements the modelling results in terms of illuminating the magnitude of the role that transit plays in successful global cities.

For, as discussed in Chapter 4 of this paper, Toronto is competing on the world stage for investment, people and jobs. We are proud of our global status and of being the "go to" place for people from around the world looking for a better future. But every successful global urban region that we are competing with, and whom we view as our peers, has a transit system in which they are constantly investing in terms of both its operations and its state of good repair. In the 1980's and 1990's the world literally came to Toronto to learn about how to "do transit right". But failure since then at both the provincial and municipal levels to adequately invest in transit at a level that is commensurate with our growth has put the legacy of earlier investments and the potential for future growth in jeopardy. We simply cannot continue to live off the investments of the past. We must continue to maintain a "virtuous cycle" of investing in our present and our future and avoid the potentially disastrous path of disinvesting in transit and thereby creating a "vicious cycle" of disinvestment, declining ridership, increased road congestion (and many other ills), and loss of economic productivity, all leading to inability to invest in needed infrastructure – ad infinitum. There is a huge difference between "cutting costs" and "spending wisely".

Maintaining a state of system good repair is an absolutely essential piece of the overall puzzle. It is fine to say that transit is fundamental to a productive, healthy city, but this is only true if the transit system can actually deliver a reliable, attractive service that is competitive to the private car and that truly meets the needs of the city's residents. As discussed in Chapter 6 of this paper, maintaining the reliability of the public transit system (getting people to where they need to go on time, not just within a reasonable travel time but with minimal unexpected delay) is a challenging, but critical, task. What trip-makers see is whether the train or the bus shows up on time and whether they experience any unexpected delays during their journey. What they do not see is the investment in maintaining and upgrading signalling systems, and track and vehicle maintenance, and investment in new vehicles and technologies, and the on-going service and operational planning that goes into constantly fine-tuning service delivery, and the myriad other functions that the TTC undertakes day-in and day-out to ensure, as best as possible, that the buses run on time and that people can get on a train in rush hour. The TTC has invested over the past number of years in adding service in high growth areas and to improve service reliability, but these investments in improved service must continue if the TTC is to meet current and expected future needs effectively.

But public transit addresses many more city objectives beyond moving people and keeping the economy going and growing. Toronto has extremely aggressive objectives with respect to greenhouse gas emission reductions/elimination in its TransformTO program. While many things need to happen if this program is to succeed, as discussed in this paper's Chapter 7, public transit is an essential component of this overall program. Climate change goals within Toronto and elsewhere simply will not be met without decarbonizing the transportation sector. The TTC is working aggressively to decarbonize its fleet (TTC, 2022), but investment in this process is required if it is to succeed and contribute to the City's climate change goals. Fundamentally changing our mode of behaviour is hard work. Passing a policy document with grand objectives is one thing. Being willing to invest in actually achieving these objectives is another.

Further, public transit investment is also key to reducing transportation system air pollution and to thereby improving the health of Toronto's population. We spend billions of dollars on health care; proactively reducing a host of health problems from respiratory diseases through to obesity-related illness by investing in maintaining and improving our transit system is another important society benefit.

Similarly, Toronto is home to one of the most diverse (if not most diverse) populations in the world. We are justly proud of our diversity, but we also recognize that we have a way to go to be the truly inclusive and equitable society to which we aspire. Again, public transit is not the sole solution to this challenge, but, as discussed in Chapter 8 of this paper, it is a central component of moving to the truly equitable and inclusive city which is our goal. The TTC's 5 Year Service Plan targets improving transit access to employment opportunities for Neighbourhood Improvement Areas, while a cornerstone of the 2022-2031 Capital Budget and Plan is funding to complete the Easier Access Program, which will see all subway stations fully accessible by 2025.

Thus, the picture that this paper has described in detail is one in which investment in public transit infrastructure and services is a "win-win-win" with respect to the economy, the environment and social equity. To the contrary, failure to invest in the name of short-run "cost cutting" is a "lose-lose-lose" proposition that will leave the city poorer and will actively reduce our ability to meet our economic, environmental and societal objectives.

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Appendix A
Additional 2016 TTS Trip Tables

Table I.1: 2016 GTHA Total Trips, All Modes

(a) Morning & Afternoon Peak Periods

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	226642	302806	22115	49193	46074	17363	4459	668,652
Rest of Toromto	324612	1542903	56802	209936	142737	20774	4654	2,302,418
Durham	23237	58938	442537	28676	5204	842	484	559,918
York	55316	214231	28070	745826	53282	6476	2116	1,105,317
Peel	51192	147723	5430	55039	949813	78878	12401	1,300,476
Halton	19092	20987	633	5726	82108	385388	46716	560,650
Hamilton	4623	4324	443	1757	11735	46906	417194	486,982
Total	704,714	2,291,912	556,030	1,096,153	1,290,953	556,627	488,024	6,984,413

(b)Off-Peak (Midday; Evening; Night) Periods

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	199173	220699	10775	25459	24642	7567	2802	491,117
Rest of Toromto	199302	1473501	42693	161275	108413	13896	5140	2,004,220
Durham	9615	39776	479532	17097	5613	616	493	552,742
York	19532	156702	17282	674864	33698	3327	1426	906,831
Peel	20146	105088	5310	33635	880724	54789	7333	1,107,025
Halton	6117	13383	728	4096	50639	393727	33850	502,540
Hamilton	2854	5732	424	1658	7744	32983	440348	491,743
Total	456,739	2,014,881	556,744	918,084	1,111,473	506,905	491,392	6,056,218

(c) 24-Hour (All-Day)

Org\Dest	PD1	Rest of Toronto	Durham	York	Peel	Halton	Hamilton	Total
PD1	425815	523505	32890	74652	70716	24930	7261	1,159,769
Rest of Toromto	523914	3016404	99495	371211	251150	34670	9794	4,306,638
Durham	32852	98714	922069	45773	10817	1458	977	1,112,660
York	74848	370933	45352	1420690	86980	9803	3542	2,012,148
Peel	71338	252811	10740	88674	1830537	133667	19734	2,407,501
Halton	25209	34370	1361	9822	132747	779115	80566	1,063,190
Hamilton	7477	10056	867	3415	19479	79889	857542	978,725
Total	1,161,453	4,306,793	1,112,774	2,014,237	2,402,426	1,063,532	979,416	13,040,631

Table I.2: 2016 TTC Trips within the City of Toronto

(a) Morning & Afternoon Peak Periods

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	55640	26043	18850	29071	7523	24329	3445	12076	2489	6549	21773	5713	13203	3100	2269	9101	241,174
PD 2	26831	9474	4711	3464	717	2063	889	2344	766	1525	1422	351	1114	55	277	400	56,403
PD 3	19751	5682	13121	5444	706	764	481	1508	1342	4317	1874	508	635	153	148	457	56,891
PD 4	30681	3674	4996	11692	3762	3644	608	1608	641	1978	6059	1486	3127	678	571	1063	76,268
PD 5	8521	637	771	3815	4258	1306	133	284	126	449	1632	1505	2041	252	366	640	26,736
PD 6	26029	1866	1105	3980	1126	8612	409	1118	127	555	1350	570	3472	829	450	822	52,420
PD 7	3848	780	580	768	111	328	1313	1769	372	188	329	0	168	34	74	84	10,746
PD 8	14535	2450	1542	1835	127	934	2090	7168	1565	710	808	132	365	94	236	148	34,739
PD 9	3127	641	1673	799	296	204	306	1671	2873	2006	370	0	210	126	44	128	14,474
PD 10	6775	1682	4407	1698	788	690	160	655	2116	8684	3290	476	782	84	216	695	33,198
PD 11	23000	1077	1391	5505	1947	1350	380	822	346	3178	8565	2050	1120	181	372	1320	52,604
PD 12	5650	324	307	1393	2066	557	29	148	64	562	1522	1677	1115	178	366	1332	17,290
PD 13	13603	1252	743	3458	2478	3718	134	315	122	712	1082	1075	13550	1623	2694	4315	50,874
PD 14	3051	94	53	530	169	632	0	253	117	125	158	83	1559	1874	793	346	9,837
PD 15	2671	220	131	601	374	563	44	160	44	204	178	349	2867	585	1730	2244	12,965
PD 16	9658	434	452	1091	681	659	63	99	142	868	1422	1208	4154	278	1769	8174	31,152
Total	253,371	56,330	54,833	75,144	27,129	50,353	10,484	31,998	13,252	32,610	51,834	17,183	49,482	10,124	12,375	31,269	777,771

(b)Off-Peak (Midday; Evening; Night) Periods

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	45907	20565	11789	18995	4688	18072	1737	7349	1996	4216	11236	2497	7969	1734	2069	4196	165,015
PD 2	19236	12474	5734	2621	437	2151	820	2662	388	1147	664	64	347	91	138	214	49,188
PD 3	12197	4460	14576	3004	278	947	298	1325	1111	3439	1162	204	378	83	40	272	43,774
PD 4	17793	2212	3894	7953	2226	2630	366	722	355	1240	3038	862	1129	323	348	664	45,755
PD 5	3975	477	418	2121	3556	443	106	281	251	648	1298	1534	1885	90	415	767	18,265
PD 6	14724	2408	993	2472	810	10394	76	421	172	616	594	105	3054	817	621	397	38,674
PD 7	1914	723	254	136	101	108	1084	1689	237	140	73	29	17	18	47	0	6,570
PD 8	5824	2238	1119	448	310	471	1164	6342	1549	599	146	37	310	64	0	0	20,621
PD 9	1549	342	802	227	169	51	297	1299	2890	1990	260	133	22	0	27	38	10,096
PD 10	4328	772	3354	1477	347	585	164	650	1513	9189	2218	513	314	146	356	752	26,678
PD 11	10453	730	1517	3644	1146	467	81	304	345	2524	7084	1279	630	128	251	962	31,545
PD 12	2570	84	224	1006	949	112	0	0	70	509	1729	2296	1153	47	270	1324	12,343
PD 13	7436	279	326	946	1264	3066	51	310	132	399	797	1084	13919	1816	3241	3860	38,926
PD 14	1708	74	96	344	153	935	22	18	20	112	149	256	2190	1080	818	308	8,283
PD 15	1757	170	82	326	512	283	47	103	97	171	353	179	3383	737	2620	1716	12,536
PD 16	3662	283	233	530	605	439	21	65	38	789	929	1347	3874	254	2317	7901	23,287
Total	155,033	48,291	45,411	46,250	17,551	41,154	6,334	23,540	11,164	27,728	31,730	12,419	40,574	7,428	13,578	23,371	551,556

(c) 24-Hour (All-Day)

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	101,547	46,608	30,639	48,066	12,211	42,401	5,182	19,425	4,485	10,765	33,009	8,210	21,172	4,834	4,338	13,297	406,189
PD 2	46,067	21,948	10,445	6,085	1,154	4,214	1,709	5,006	1,154	2,672	2,086	415	1,461	146	415	614	105,591
PD 3	31,948	10,142	27,697	8,448	984	1,711	779	2,833	2,453	7,756	3,036	712	1,013	236	188	729	100,665
PD 4	48,474	5,886	8,890	19,645	5,988	6,274	974	2,330	996	3,218	9,097	2,348	4,256	1,001	919	1,727	122,023
PD 5	12,496	1,114	1,189	5,936	7,814	1,749	239	565	377	1,097	2,930	3,039	3,926	342	781	1,407	45,001
PD 6	40,753	4,274	2,098	6,452	1,936	19,006	485	1,539	299	1,171	1,944	675	6,526	1,646	1,071	1,219	91,094
PD 7	5,762	1,503	834	904	212	436	2,397	3,458	609	328	402	29	185	52	121	84	17,316
PD 8	20,359	4,688	2,661	2,283	437	1,405	3,254	13,510	3,114	1,309	954	169	675	158	236	148	55,360
PD 9	4,676	983	2,475	1,026	465	255	603	2,970	5,763	3,996	630	133	232	126	71	166	24,570
PD 10	11,103	2,454	7,761	3,175	1,135	1,275	324	1,305	3,629	17,873	5,508	989	1,096	230	572	1,447	59,876
PD 11	33,453	1,807	2,908	9,149	3,093	1,817	461	1,126	691	5,702	15,649	3,329	1,750	309	623	2,282	84,149
PD 12	8,220	408	531	2,399	3,015	669	29	148	134	1,071	3,251	3,973	2,268	225	636	2,656	29,633
PD 13	21,039	1,531	1,069	4,404	3,742	6,784	185	625	254	1,111	1,879	2,159	27,469	3,439	5,935	8,175	89,800
PD 14	4,759	168	149	874	322	1,567	22	271	137	237	307	339	3,749	2,954	1,611	654	18,120
PD 15	4,428	390	213	927	886	846	91	263	141	375	531	528	6,250	1,322	4,350	3,960	25,501
PD 16	13,320	717	685	1,621	1,286	1,098	84	164	180	1,657	2,351	2,555	8,028	532	4,086	16,075	54,439

2016 TTC Trips within the City of Toronto Mode Shares (% of O-D Total Trips)

🟩 Trips to/from PD1

🟦 O-D pair with mode share above the City-wide average

Morning & Afternoon Peak Periods

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	24.5%	50.6%	68.0%	60.7%	53.6%	55.6%	42.0%	61.5%	65.2%	70.5%	86.4%	75.0%	69.6%	52.0%	45.0%	64.3%	45.6%
PD 2	52.9%	16.7%	34.7%	47.4%	36.2%	56.1%	29.4%	23.7%	38.1%	54.5%	53.2%	47.0%	51.9%	17.1%	56.3%	38.1%	35.4%
PD 3	65.5%	37.4%	21.5%	34.6%	28.1%	32.0%	34.4%	18.2%	25.6%	35.0%	32.2%	28.5%	24.5%	29.8%	35.7%	20.4%	34.0%
PD 4	59.4%	52.1%	33.6%	12.8%	23.4%	33.3%	50.0%	43.3%	43.5%	39.5%	41.7%	44.3%	44.6%	44.8%	48.2%	30.7%	32.5%
PD 5	52.6%	37.9%	28.4%	24.9%	12.1%	24.3%	25.0%	22.4%	12.2%	18.6%	21.4%	26.7%	20.9%	19.1%	23.8%	12.7%	23.7%
PD 6	56.6%	57.5%	41.9%	35.6%	20.1%	13.3%	47.3%	50.7%	23.3%	36.0%	47.5%	30.5%	34.0%	20.4%	27.9%	29.7%	32.4%
PD 7	40.5%	24.8%	32.0%	56.1%	21.1%	49.1%	9.3%	17.4%	27.8%	20.1%	47.7%	0.0%	49.3%	39.1%	66.1%	23.7%	23.7%
PD 8	61.8%	22.9%	20.0%	47.8%	10.4%	44.6%	18.6%	9.6%	21.4%	21.7%	36.2%	25.8%	33.4%	23.7%	55.4%	17.6%	23.0%
PD 9	62.1%	33.7%	31.3%	44.7%	37.0%	29.0%	23.6%	23.4%	9.7%	30.1%	25.1%	0.0%	32.5%	64.3%	15.5%	9.6%	22.3%
PD 10	71.9%	61.5%	33.4%	35.4%	31.5%	50.2%	13.7%	16.4%	29.1%	18.9%	31.8%	28.9%	31.3%	33.3%	24.5%	27.1%	30.0%
PD 11	85.4%	47.4%	29.3%	37.9%	23.3%	49.6%	53.3%	39.2%	20.0%	31.7%	14.3%	26.2%	24.3%	35.1%	25.7%	27.3%	34.4%
PD 12	69.5%	44.1%	23.8%	43.8%	30.7%	30.1%	11.1%	22.6%	9.4%	30.0%	21.1%	9.7%	24.8%	29.0%	41.5%	20.6%	27.7%
PD 13	68.5%	61.7%	38.7%	46.5%	22.9%	34.2%	34.6%	28.2%	17.9%	26.0%	23.1%	23.3%	16.0%	15.9%	32.5%	20.3%	26.6%
PD 14	48.6%	27.5%	15.3%	34.8%	15.4%	15.8%	0.0%	52.0%	69.6%	52.5%	23.8%	20.8%	15.4%	11.4%	28.9%	15.8%	20.9%
PD 15	44.1%	41.4%	25.4%	44.2%	22.7%	29.4%	27.5%	42.0%	20.4%	22.5%	11.9%	33.7%	28.9%	21.3%	7.6%	29.2%	21.8%
PD 16	63.5%	38.9%	19.7%	31.6%	14.0%	25.1%	17.2%	13.7%	11.9%	37.9%	30.1%	18.0%	20.0%	17.6%	25.7%	11.5%	21.3%
Total	46.0%	35.0%	33.9%	32.3%	23.8%	31.5%	23.3%	21.8%	20.6%	30.1%	34.1%	27.8%	26.1%	21.7%	22.5%	21.2%	32.4%

(b)Off-Peak (Midday; Evening; Night) Periods

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	23.0%	48.2%	52.1%	52.3%	48.6%	51.3%	33.4%	52.9%	63.1%	70.7%	75.3%	57.0%	68.4%	48.6%	52.5%	55.6%	39.3%
PD 2	47.8%	19.5%	32.7%	43.3%	39.6%	52.0%	23.1%	23.5%	32.0%	50.2%	34.9%	18.8%	30.1%	27.6%	27.0%	27.8%	31.4%
PD 3	61.9%	30.4%	23.7%	22.0%	12.5%	39.7%	19.0%	17.1%	24.6%	25.6%	22.6%	22.7%	25.1%	26.8%	14.5%	15.0%	28.9%
PD 4	52.6%	37.2%	27.1%	10.2%	17.4%	27.5%	39.2%	34.4%	26.8%	34.1%	25.7%	38.0%	24.7%	32.4%	31.2%	27.8%	24.6%
PD 5	50.4%	32.2%	19.8%	16.1%	11.3%	9.5%	29.1%	24.6%	47.6%	38.0%	17.3%	25.5%	17.3%	9.1%	29.6%	18.8%	19.1%
PD 6	46.2%	52.3%	40.0%	24.3%	19.7%	16.3%	9.9%	32.7%	36.7%	52.5%	35.0%	8.2%	24.4%	14.7%	48.9%	22.9%	26.7%
PD 7	35.7%	22.7%	19.2%	20.6%	36.3%	14.6%	7.9%	14.4%	28.7%	18.1%	27.8%	22.8%	4.4%	15.0%	20.3%	0.0%	16.5%
PD 8	55.0%	21.2%	13.2%	20.7%	21.3%	30.3%	10.3%	7.1%	20.1%	17.7%	12.9%	6.1%	42.6%	25.3%	0.0%	0.0%	13.7%
PD 9	61.7%	32.2%	19.7%	18.1%	32.8%	18.5%	32.7%	15.8%	9.2%	30.0%	21.9%	46.5%	3.5%	0.0%	27.6%	5.2%	16.9%
PD 10	69.6%	33.9%	27.5%	36.3%	23.1%	38.8%	35.7%	22.7%	27.4%	21.6%	22.2%	39.3%	17.7%	64.0%	50.8%	39.5%	28.0%
PD 11	79.0%	35.8%	24.1%	30.3%	16.4%	29.5%	33.3%	25.3%	30.7%	25.5%	12.3%	17.8%	19.6%	19.3%	30.9%	20.5%	24.5%
PD 12	60.0%	35.0%	20.4%	45.2%	19.9%	10.1%	0.0%	0.0%	37.6%	38.1%	22.4%	12.6%	28.1%	12.5%	28.0%	15.9%	22.2%
PD 13	70.0%	28.8%	18.4%	21.9%	12.0%	25.4%	13.7%	36.3%	15.4%	25.2%	24.0%	29.0%	16.0%	17.9%	29.3%	18.6%	21.6%
PD 14	48.1%	27.9%	25.9%	34.3%	14.5%	18.7%	51.2%	12.3%	100.0%	69.1%	25.4%	44.2%	21.7%	7.2%	24.9%	23.2%	19.5%
PD 15	54.0%	48.9%	26.6%	33.6%	36.4%	30.2%	35.3%	49.5%	60.6%	34.0%	33.9%	21.7%	37.1%	23.9%	11.9%	21.1%	23.9%
PD 16	59.3%	34.4%	16.4%	27.1%	15.9%	21.0%	11.8%	8.7%	5.2%	41.5%	19.4%	17.0%	17.9%	17.3%	26.1%	11.3%	17.3%
Total	38.9%	31.1%	28.7%	24.6%	18.7%	28.1%	15.9%	15.3%	18.7%	28.6%	24.3%	22.2%	22.4%	17.3%	24.0%	17.3%	26.4%

(c) 24-Hour (All-Day)

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	23.8%	49.5%	60.9%	57.1%	51.6%	53.6%	38.7%	57.9%	64.2%	70.6%	82.3%	68.4%	69.1%	50.7%	48.3%	61.3%	42.8%
PD 2	50.6%	18.1%	33.6%	45.5%	37.4%	53.9%	26.0%	23.6%	35.8%	52.6%	45.6%	38.2%	44.3%	22.4%	41.4%	33.8%	33.4%
PD 3	64.1%	34.0%	22.6%	28.8%	20.8%	35.9%	26.3%	17.7%	25.1%	30.1%	27.7%	26.5%	24.7%	28.6%	27.2%	18.0%	31.6%
PD 4	56.7%	45.3%	30.4%	11.6%	20.7%	30.6%	45.3%	40.1%	35.6%	37.2%	34.5%	41.7%	36.8%	39.9%	40.0%	29.5%	29.0%
PD 5	51.9%	35.2%	24.6%	20.8%	11.7%	17.4%	26.7%	23.5%	24.1%	26.6%	19.4%	26.1%	19.0%	14.9%	26.6%	15.4%	21.6%
PD 6	52.4%	54.4%	41.0%	30.2%	19.9%	14.8%	29.7%	44.1%	29.5%	43.1%	42.8%	21.4%	28.7%	17.1%	37.2%	27.1%	29.7%
PD 7	38.7%	23.8%	26.6%	44.6%	26.4%	31.0%	8.6%	15.8%	28.2%	19.2%	42.2%	7.0%	25.5%	25.1%	35.2%	19.9%	20.3%
PD 8	59.7%	22.1%	16.4%	38.0%	16.3%	38.5%	14.4%	8.2%	20.7%	19.7%	28.4%	15.1%	37.1%	24.3%	41.3%	9.4%	18.4%
PD 9	62.0%	33.2%	26.3%	33.7%	35.4%	26.0%	27.4%	19.3%	9.5%	30.1%	23.7%	14.8%	18.2%	60.6%	18.6%	8.0%	19.7%
PD 10	71.0%	49.0%	30.6%	35.8%	28.3%	44.2%	19.9%	19.0%	28.3%	20.2%	27.1%	33.5%	25.6%	47.9%	36.2%	32.4%	29.1%
PD 11	83.3%	41.9%	26.3%	34.4%	20.1%	42.2%	48.2%	34.1%	24.2%	28.7%	13.3%	22.2%	22.4%	26.2%	27.5%	23.9%	29.9%
PD 12	66.2%	41.9%	22.2%	44.4%	26.2%	22.6%	6.8%	13.6%	15.5%	33.4%	21.8%	11.2%	26.4%	22.7%	34.5%	18.0%	25.1%
PD 13	69.1%	51.1%	29.0%	37.5%	17.6%	29.6%	24.3%	31.7%	16.5%	25.7%	23.5%	25.9%	16.0%	16.9%	30.7%	19.4%	24.2%
PD 14	48.4%	27.7%	20.8%	34.6%	15.0%	17.4%	15.3%	42.8%	72.9%	59.3%	24.6%	34.7%	18.5%	9.4%	26.7%	18.6%	20.2%
PD 15	47.6%	44.4%	25.9%	39.8%	29.0%	29.7%	31.1%	44.7%	37.5%	26.6%	20.9%	28.4%	32.9%	22.7%	9.7%	25.1%	22.8%
PD 16	62.3%	37.0%	18.5%	29.9%	14.8%	23.3%	15.4%	11.2%	9.3%	39.5%	24.7%	17.4%	19.0%	17.5%	25.9%	11.4%	19.4%

Table I.3: 2016 Total Trips within the City of Toronto, All Modes

(a) Morning & Afternoon Peak Periods

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	226,642	51,443	27,703	47,914	14,031	43,795	8,204	19,649	3,820	9,290	25,212	7,619	18,977	5,961	5,044	14,146	529,450
PD 2	50,727	56,884	13,557	7,310	1,983	3,678	3,025	9,898	2,013	2,798	2,673	747	2,148	322	492	1,049	159,304
PD 3	30,155	15,178	60,915	15,720	2,509	2,386	1,397	8,276	5,252	12,319	5,822	1,783	2,589	514	415	2,235	167,465
PD 4	51,640	7,057	14,871	91,615	16,097	10,949	1,215	3,714	1,475	5,007	14,532	3,356	7,016	1,512	1,185	3,462	234,703
PD 5	16,206	1,682	2,718	15,323	35,185	5,372	531	1,266	1,035	2,410	7,616	5,635	9,764	1,317	1,536	5,049	112,645
PD 6	45,960	3,248	2,639	11,183	5,606	64,727	865	2,205	545	1,542	2,840	1,870	10,218	4,065	1,612	2,769	161,894
PD 7	9,509	3,139	1,814	1,369	526	668	14,075	10,155	1,337	935	690	290	341	87	112	354	45,401
PD 8	23,532	10,695	7,717	3,839	1,222	2,096	11,221	74,724	7,320	3,278	2,231	512	1,092	396	426	841	151,142
PD 9	5,033	1,900	5,338	1,788	799	704	1,295	7,146	29,606	6,668	1,476	611	647	196	283	1,329	64,819
PD 10	9,425	2,733	13,213	4,791	2,500	1,374	1,166	3,994	7,281	45,941	10,348	1,648	2,499	252	881	2,566	110,612
PD 11	26,925	2,272	4,747	14,541	8,370	2,723	713	2,097	1,726	10,017	59,742	7,811	4,609	515	1,450	4,841	153,099
PD 12	8,124	734	1,291	3,181	6,734	1,849	262	656	681	1,874	7,215	17,248	4,493	614	882	6,479	62,317
PD 13	19,847	2,028	1,921	7,440	10,818	10,867	387	1,117	683	2,738	4,678	4,607	84,521	10,177	8,285	21,302	191,416
PD 14	6,274	342	347	1,522	1,099	4,004	101	487	168	238	663	399	10,147	16,433	2,748	2,196	47,168
PD 15	6,050	531	515	1,360	1,650	1,917	160	381	216	907	1,493	1,037	9,907	2,741	22,788	7,689	59,342
PD 16	15,206	1,116	2,294	3,456	4,857	2,623	366	725	1,198	2,293	4,718	6,718	20,764	1,583	6,896	71,374	146,187
Total	551,255	160,982	161,600	232,352	113,986	159,732	44,983	146,490	64,356	108,255	151,949	61,891	189,732	46,685	55,035	147,681	2,396,964

(b)Off-Peak (Midday; Evening; Night) Periods

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	199,173	42,637	22,644	36,301	9,641	35,254	5,200	13,889	3,163	5,963	14,917	4,381	11,656	3,571	3,938	7,546	419,874
PD 2	40,268	64,132	17,525	6,057	1,103	4,134	3,550	11,348	1,212	2,283	1,905	340	1,151	330	511	770	156,619
PD 3	19,701	14,677	61,632	13,635	2,232	2,385	1,569	7,739	4,512	13,457	5,134	900	1,505	310	275	1,819	151,482
PD 4	33,801	5,941	14,348	78,205	12,780	9,558	934	2,096	1,325	3,635	11,803	2,271	4,563	997	1,114	2,391	185,762
PD 5	7,891	1,480	2,115	13,166	31,602	4,679	364	1,143	527	1,707	7,500	6,016	10,920	984	1,403	4,072	95,569
PD 6	31,853	4,602	2,482	10,190	4,112	63,758	770	1,288	469	1,173	1,698	1,283	12,503	5,570	1,269	1,737	144,757
PD 7	5,365	3,183	1,322	659	278	739	13,638	11,741	826	775	263	127	385	120	232	69	39,722
PD 8	10,582	10,557	8,500	2,169	1,457	1,555	11,318	89,707	7,690	3,378	1,129	604	727	253	146	729	150,501
PD 9	2,511	1,062	4,077	1,256	515	275	909	8,216	31,328	6,628	1,185	286	629	12	98	736	59,723
PD 10	6,215	2,277	12,183	4,074	1,504	1,508	459	2,861	5,526	42,620	9,993	1,307	1,775	228	701	1,905	95,136
PD 11	13,230	2,039	6,290	12,036	7,008	1,585	243	1,201	1,125	9,885	57,490	7,176	3,207	663	813	4,695	128,686
PD 12	4,286	240	1,098	2,225	4,776	1,113	165	429	186	1,335	7,720	18,276	4,098	376	964	8,308	55,595
PD 13	10,622	969	1,768	4,310	10,499	12,064	373	854	858	1,582	3,316	3,741	86,933	10,150	11,053	20,764	179,856
PD 14	3,553	265	371	1,003	1,052	5,002	43	146	20	162	586	579	10,081	14,934	3,279	1,328	42,404
PD 15	3,251	348	308	970	1,406	936	133	208	160	503	1,042	825	9,118	3,089	21,948	8,116	52,361
PD 16	6,174	823	1,418	1,959	3,806	2,094	178	743	731	1,901	4,793	7,933	21,587	1,464	8,882	70,154	134,640
Total	398,476	155,232	158,081	188,215	93,771	146,639	39,846	153,609	59,658	96,987	130,474	56,045	180,838	43,051	56,626	135,139	2,092,687

(c) 24-Hour (All-Day)

Org\Dest	PD 1	PD 2	PD 3	PD 4	PD 5	PD 6	PD 7	PD 8	PD 9	PD 10	PD 11	PD 12	PD 13	PD 14	PD 15	PD 16	Total
PD 1	425,815	94,080	50,347	84,215	23,672	79,049	13,404	33,538	6,983	15,253	40,129	12,000	30,633	9,532	8,982	21,692	949,324
PD 2	90,995	121,016	31,082	13,367	3,086	7,812	6,575	21,246	3,225	5,081	4,578	1,087	3,299	652	1,003	1,819	315,923
PD 3	49,856	29,855	122,547	29,355	4,741	4,771	2,966	16,015	9,764	25,776	10,956	2,683	4,094	824	690	4,054	318,947
PD 4	85,441	12,998	29,219	169,820	28,877	20,507	2,149	5,810	2,800	8,642	26,335	5,627	11,579	2,509	2,299	5,853	420,465
PD 5	24,097	3,162	4,833	28,489	66,787	10,051	895	2,409	1,562	4,117	15,116	11,651	20,684	2,301	2,939	9,121	208,214
PD 6	77,813	7,850	5,121	21,373	9,718	128,485	1,635	3,493	1,014	2,715	4,538	3,153	22,721	9,635	2,881	4,506	306,651
PD 7	14,874	6,322	3,136	2,028	804	1,407	27,713	21,896	2,163	1,710	953	417	726	207	344	423	85,123
PD 8	34,114	21,252	16,217	6,008	2,679	3,651	22,539	164,431	15,010	6,656	3,360	1,116	1,819	649	572	1,570	301,643
PD 9	7,544	2,962	9,415	3,044	1,314	979	2,204	15,362	60,934	13,296	2,661	897	1,276	208	381	2,065	124,542
PD 10	15,640	5,010	25,396	8,865	4,004	2,882	1,625	6,855	12,807	88,561	20,341	2,955	4,274	480	1,582	4,471	205,748
PD 11	40,155	4,311	11,037	26,577	15,378	4,308	956	3,298	2,851	19,902	117,232	14,987	7,816	1,178	2,263	9,536	281,785
PD 12	12,410	974	2,389	5,406	11,510	2,962	427	1,085	867	3,209	14,935	35,524	8,591	990	1,846	14,787	117,912
PD 13	30,469	2,997	3,689	11,750	21,317	22,931	760	1,971	1,541	4,320	7,994	8,348	171,454	20,327	19,338	42,066	371,272
PD 14	9,827	607	718	2,525	2,151	9,006	144	633	188	400	1,249	978	20,228	31,367	6,027	3,524	89,572
PD 15	9,301	879	823	2,330	3,056	2,853	293	589	376	1,410	2,535	1,862	19,025	5,830	44,736	15,805	111,703
PD 16	21,380	1,939	3,712	5,415	8,663	4,717	544	1,468	1,929	4,194	9,511	14,651	42,351	3,047	15,778	141,528	280,827
Total	949,731	316,214	319,681	420,567	207,757	306,371	84,829	300,099	124,014	205,242	282,423	117,936	370,570	89,736	111,661	282,820	4,489,651