Transportation Pressures in the GTHA

February 2020

CANADIAN CENTRE FOR
ECONOMIC ANALYSIS

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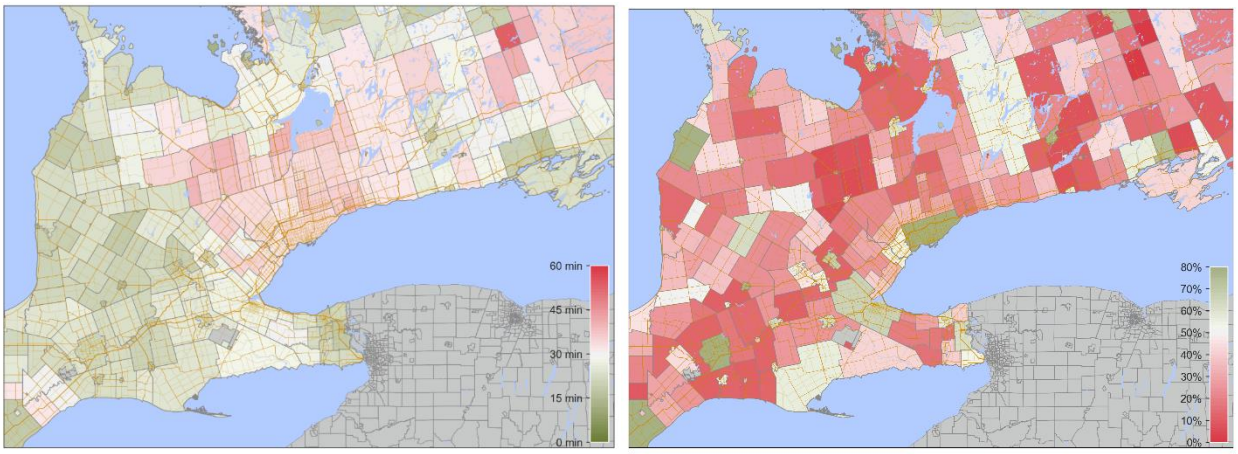
As the leading region for job creation in Ontario over the past decade and home to over half of the provincial population, the GTHA's prosperity is closely linked to that of Canada. At the heart of the region is the Toronto metropolitan area, which alone generates 52% of Ontario's GDP. Between 2006 and 2016, the population in the region has grown by 14% and the number of jobs has grown by almost 10%. By 2041, the population is expected to grow by a further 41% to over 10.1 million.

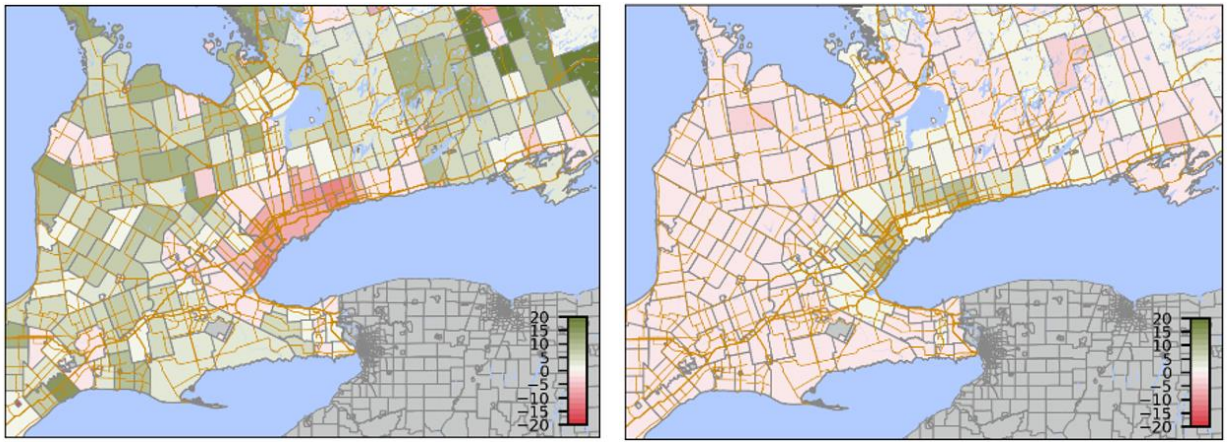
Average Commuting Times by Place of Residence (left) and percentage of labour force living and working in the same region (right), 2016



Longer commutes are a consequence of the geographical divide between home and workplace found in the region. The majority of employees in six of the nine municipalities with the largest number of jobs commute in from other municipalities. Only in Toronto, Hamilton and Mississauga do over 50% of the locally employed population also reside within the same municipal boundaries.

People who reside in the larger urban centres of the GTHA, and Toronto most notably, generally have public transit options that connect their places of residence and work. Outside of these urban cores, car ownership is a necessity. Thus, while the prevalence of public transit has increased as the main mode of commute for people residing in the GTHA, the share of private vehicle commutes has increased in the rest of the region.

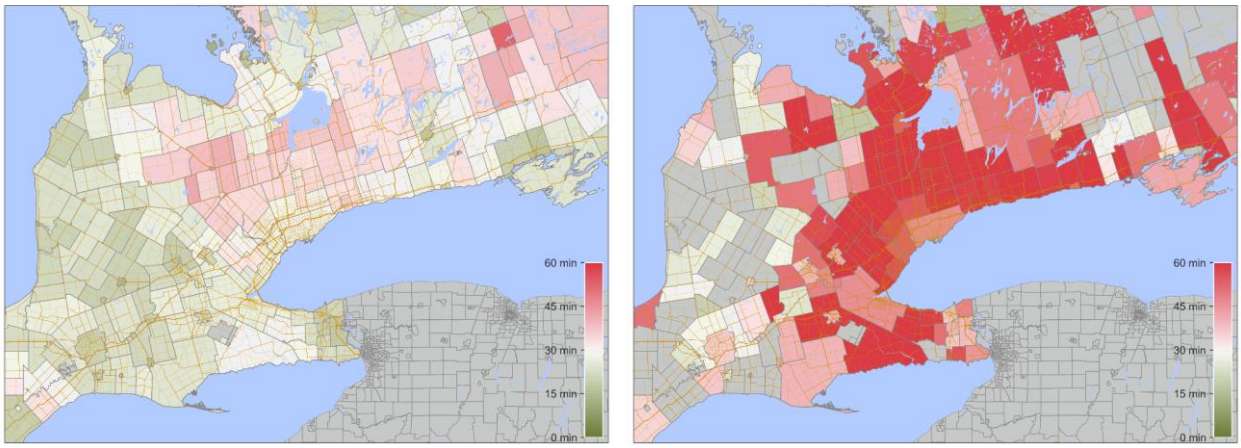
Change in private vehicle use (left) and public transit (right) as primary mode, 2006 to 2016



Present Transportation Challenges

Currently, more than half of commuters spend over 30 minutes commuting in a single direction, and for some commuters, this can even exceed an hour. This exceeds the commonly cited "Marchetti's Constant", the notion in transportation literature that on average, people are willing to commute for 30 minutes in a single direction, and hints at the pressure building up in the system. The longest commutes belong to residents of municipalities in the north of the GTHA and those for whom public transit is the primary mode, as shown in the figure below. (Note that outside the major urban centres of the GTHA, fewer people use public transit due to its limited availability with the exception of long trips on the regional GO transit lines).

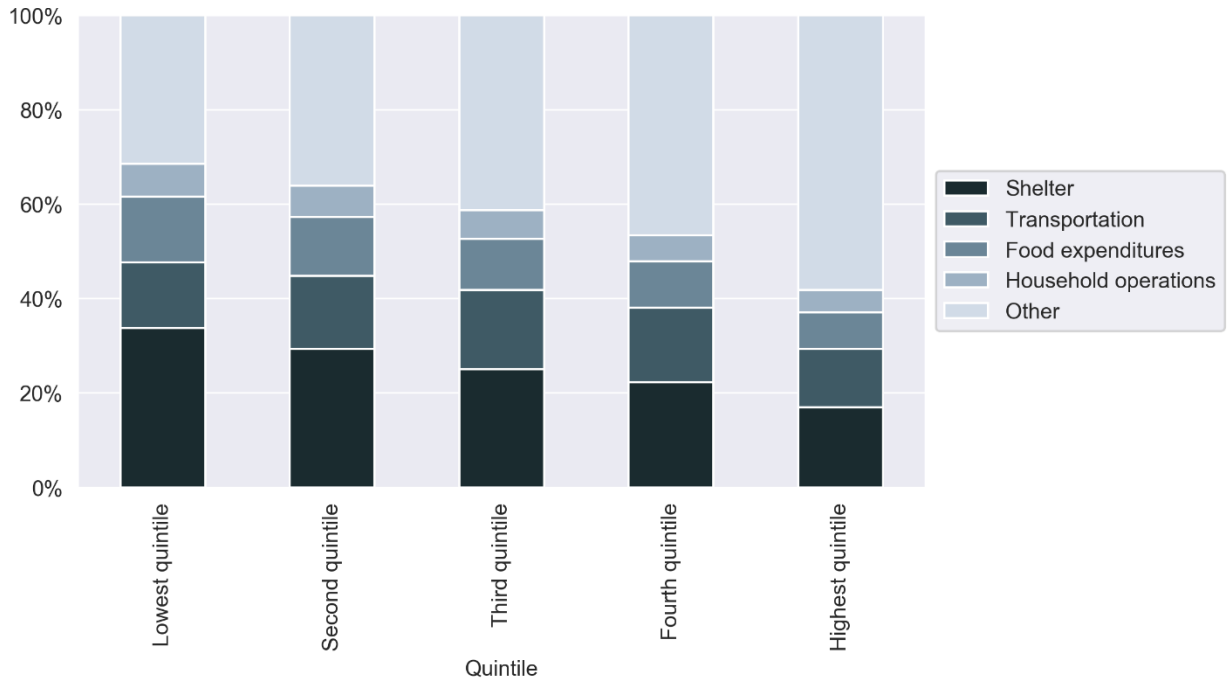
Average commute duration by car (left) and by public transit (right)



In fact, on public transit, commutes of an hour or more are twice as common as commutes lasting under 30 minutes. Public transit takes longer per kilometre than private vehicles, and it is likely because of this higher time cost that many people for whom public transit may be available and less expensive than owning a vehicle still choose to drive to work.

All type of commuting is associated with a cost, both financial and in terms of time. For lower-income households, namely those whose incomes fall in the lowest fifth of the population, transportation and housing together make up half of their total expenses, on average. Since these households are most at risk of being priced out of a given housing market, their transportation expenses are closely tied to housing costs and these are therefore best considered together. For instance, a low-income family who can no longer afford to pay rent may have to move to a neighbourhood further from the wage-earner's workplace with poor connections to public transit to afford rent. Their car maintenance and gas expenses will therefore increase, partially offsetting their rent savings. This also helps explain why, although lower-income households tend to rely more on public transit than higher-income households, private vehicles remain by far the main mode of transportation for households at every income level.

Household expenditures by income quintile in the Toronto CMA, 2016



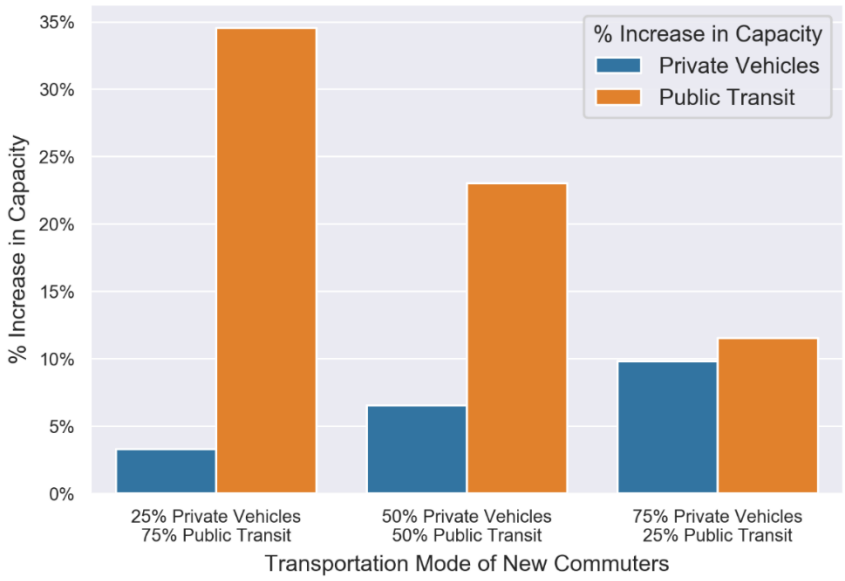
Congestion, which is caused by commuter flows in the region, imposes significant societal costs and poses a risk to regional prosperity. Past the point of capacity, every commuter's use of transportation infrastructure (whether roads, trains, subways, etc.) imposes a cost on the entire system in the form of congestion, which generally includes longer trip times, slower speeds and increased queuing. The cost to drivers is an estimated additional 840,000 hours on the road each day, with an associated economic cost of $4.9 billion annually in the GTA alone. Beyond the direct costs borne by all commuters on the overloaded system, excessive congestion can also negatively impact the labour market and economic growth. For instance, businesses that face a higher cost of doing business as a result of congestion could be discouraged from investing and growing their operations and may even relocate. Workers, facing a declining quality of life as a result of long, gridlocked commutes may also choose to leave the area, and this may also discourage people from searching for work in the region if economic conditions are

comparable elsewhere. These obstacles to investment and labour force mobility, if persistent, could have a long-term impact on the GTHA's prosperity.

Future Opportunities for Transportation in the GTHA

At the rate that employment and population are growing, daily commuting trips to the GTHA are expected to increase by 480,000 by 2030. To accommodate this growth, the capacity of both major roadways and public transit will have to increase significantly in order to avoid system overload. The figure below shows how much additional road and public transit capacity will be required as the number of commuters increases (e.g., if half of new commuters travel in private vehicles and the other half on public transit, road capacity will have to increase by less than 10% while public transit capacity will have to increase by over 20%). Evident in the figure is that public transit capacity will have to increase faster than road capacity to accommodate new commuters. Given the significant costs associated with creating new transportation infrastructure or expanding and increasing the capacity of existing infrastructure, ensuring the productivity of these investments (i.e. maximizing the capacity per dollar invested) is critical.

Future growth of transportation capacity by mode



The existing geographical disparity between where most people live and most people work in the GTHA underscores the need to harmonize transportation planning with land-use planning and economic policy. Transportation-oriented development (TOD) is a concept that fits this purpose. TOD maximizes the number of homes, businesses and other activities in proximity to transit development, creating economies of scale and rendering transportation infrastructure investments more productive. As the GTHA continues to grow, TOD can play a role in minimizing unused capacity on public transit.

Transportation infrastructure is necessary both to connect primarily residential municipalities to municipalities that are regional employment hubs and to facilitate transportation within municipalities to local employment hubs. There are a number of publicly announced plans to increase transportation

capacity and invest in additional transportation infrastructure in the GTHA. For instance, at the inter-municipal level, Metrolinx, the provincial transportation infrastructure agency, is preparing to accommodate a doubling of ridership over the next one to two decades by implementing the Regional Express Rail expansion. For private vehicle commuters, planned projects to increase capacity and connectivity include ongoing improvements to a number of main arteries that cross the region and the expansion of Highway 407 to the East with connections to Highway 401. At the intra-municipal level, there are light-rail transit projects underway in Toronto, Hamilton, and Mississauga with completion dates within the next five years. This additional transportation infrastructure, however sorely needed, will only yield benefits if investments are governed by planning best practices and if their productivity is maximized.

Emerging trends in transportation also have the potential to impact the system. One such example is the rise of "vehicle-on-demand" (VOD) services in the last decade, which in addition to taxicabs, includes technology-driven platforms such as Uber and Lyft. These have already begun to change how infrastructure is used. There is increasing evidence that VOD services actually increase the number of cars on the road, in part by reducing the number of cars sitting idle in garages and driveways. Studies have shown that their impact on public transit ridership in American cities is mixed. Cities and towns with small, less extensive public transit systems tend to see a decline in ridership following the expansion of VOD services in the area, which suggests that these offer a competing service. On the other hand, cities with larger, more extensive public transit systems have seen a small increase in transit use following their introduction, which suggests some degree of complementarity. It will be important to continue to monitor these trends and assess their relevance to the GTHA context as they develop and to consider the possible impacts of VOD services when planning future regional transportation infrastructure. Autonomous Vehicles (AV) are another emerging trend whose future impacts will become clearer as the technology matures. Nonetheless, decision-makers and planners should begin contemplating a range of adoption scenarios and modelling how each could affect commuter flows in the GTHA and change congestion patterns.

CONCLUSIONS

- The continued population and employment growth in the GTHA can exacerbate current transportation challenges.
- Without sufficient, properly leveraged and well-planned transportation infrastructure:
    - Commutes could continue to lengthen and quality of life could suffer.
    - Average commute times could increase, pushing people to look elsewhere for employment opportunities.
    - Costs of doing business may increase and the ability to attract employees could decrease, constraining regional economic growth.
- To avoid a worsening of congestion and to lessen transportation pressures, future investments in transportation infrastructure should be evaluated on the basis of their productivity to make sure every dollar invested goes to a project that will generate capacity where it is most needed.
- The alignment of residential, economic and transportation development is critical to Ontario's prosperity and future growth.

1.0 INTRODUCTION

1.1 BACKGROUND

As the leading region for job creation in Ontario over the past decade and home to over half of the provincial population, the GTHA's prosperity is closely linked to that of Ontario and Canada. At the heart of the region is the Toronto Metropolitan Area, which alone generates 52% of Ontario's GDP. Between 2006 and 2016, the population in the region has grown by 14% and the number of jobs has grown by almost 10%. By 2041, the population is expected to grow by a further 41% to over 10.1 million.

Population and employment growth in the GTHA has not occurred uniformly. Rather, job growth and residential growth have occurred in visibly distinct locations within the region. Considering the divide between places of work and residence, more and more people are relying on transportation infrastructure to get to work from home and back. Commuters travel through a network of roads, active transportation and public transit, or a combination thereof. Public transit access varies widely across the region. Most municipalities have a local system whose extensiveness depends on the size of the municipality, and a network of GO buses and trains crisscross the GTHA, with Toronto's Union Station as the central hub.

The geographical disparity between residential growth and job growth and the congestion caused by an increasing number of system users combine to lengthen the commute times of people who work and live in the GTHA. As the population continues to grow, it is important to understand the forces shaping existing commuting patterns. This is necessary to identify which parts of the transportation infrastructure are under the most pressure and to invest in relieving it. Failing to do so poses significant risks to prosperity in the GTHA, and consequently, to Ontario as a whole. Congestion, which is currently estimated to cost the GTA alone $4.9 billion annually (TomTom, 2018), could worsen and cause longer commute times, decreasing quality of life and increasing the cost of doing business in the region.

1.2 OBJECTIVES

This report presents an overview of transportation and commuting trends in the GTHA over the past decade and identifies how these could impact regional prosperity in the coming decades. The impact of factors such as population and employment growth and the emergence of new transportation technologies on these trends are discussed. The study highlights the connections between the GTHA's economic growth and its transportation infrastructure.

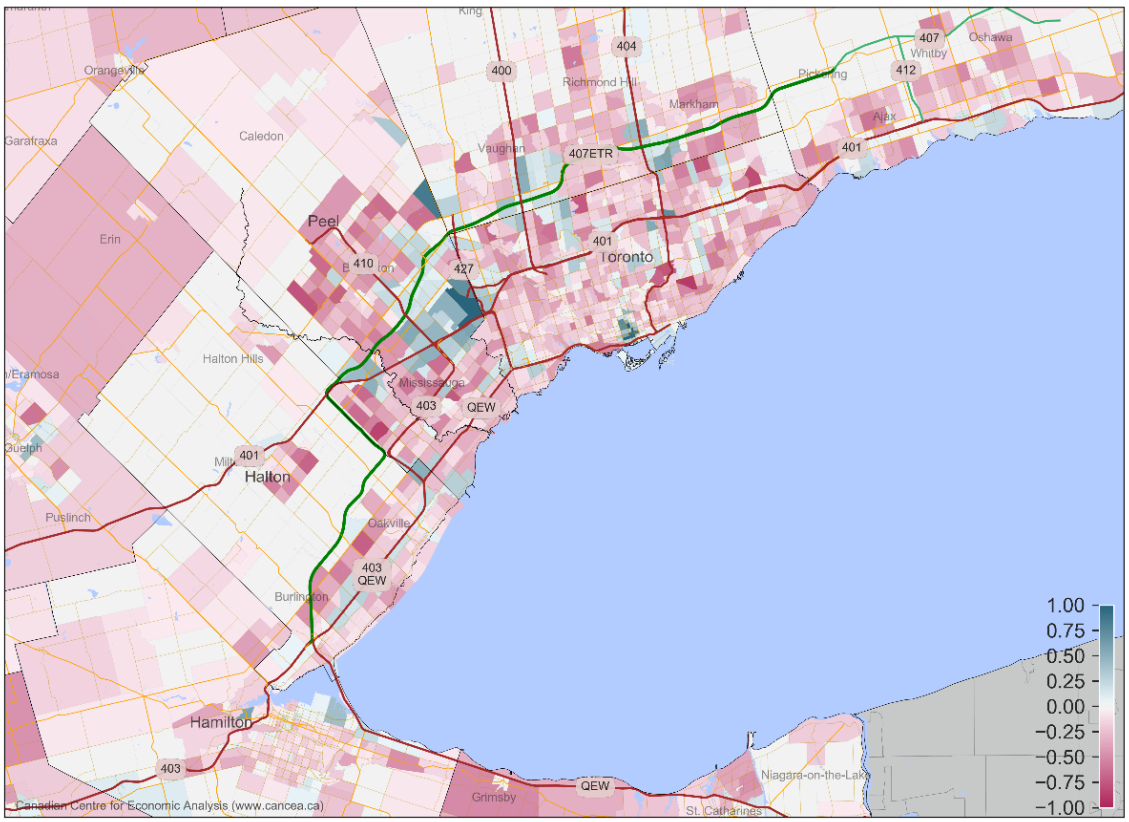
2.0 COMMUTING PATTERNS IN THE GTHA

2.1 PLACE OF WORK AND RESIDENCE

The growth of cities is shaped by the dominant mode of transportation used by residents to commute to and from work. In the GTHA, that mode is the car. Past studies have demonstrated how the car reduced the costs of travel for households, thus increasing the possible distance between home and place of work (Glaeser & Kahn, 2004). Car use has caused cities to extend outwards and "edge cities", characterized by their low-density, to emerge (Garreau, 1992). These do not replace the traditionally dense downtown of more established cities but instead contain decentralized, lower-density employment areas that are primarily accessible by car (Glaeser & Kahn, 2004). In sum, thanks to the car, people must no longer live close to where they work, nor must they live clustered together close to a transportation hub.

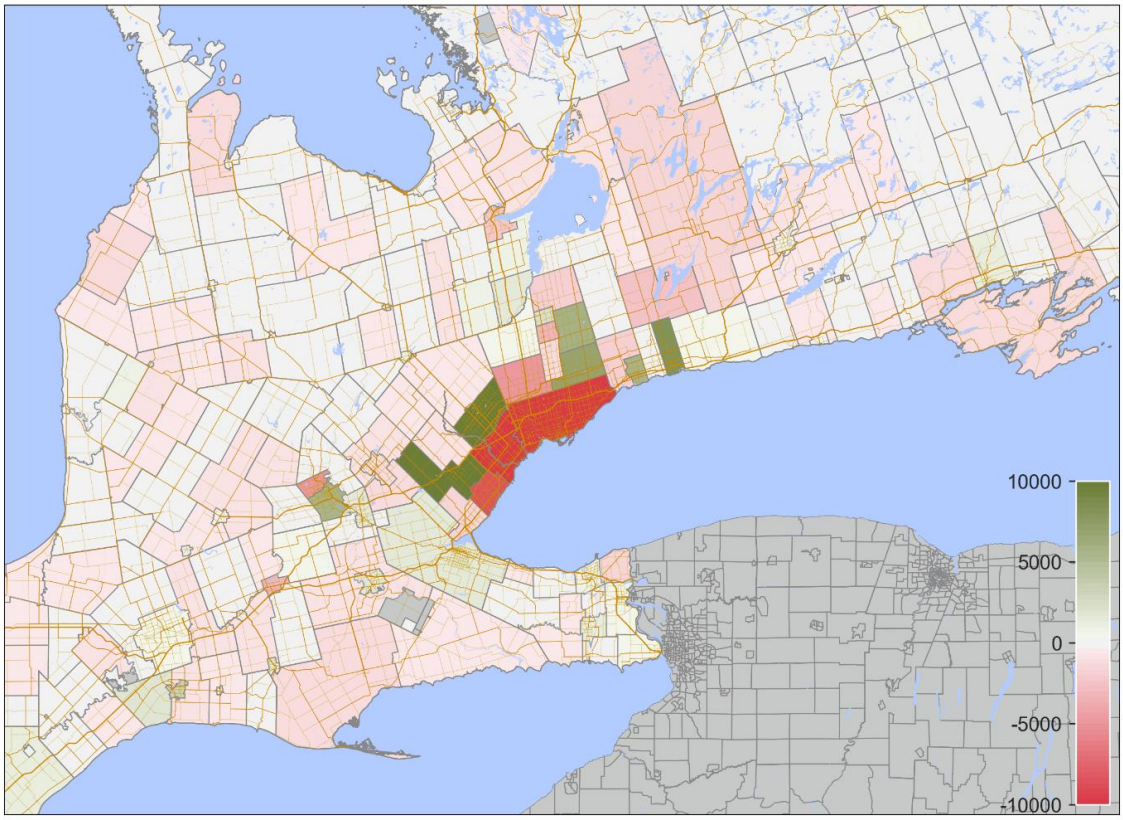
The GTHA has many of the features of this pattern of urban development, with Toronto's downtown as the densest employment core, surrounded by lower-density residential areas and secondary employment areas along major roadways in Peel and York. This pattern is evident in Figure 1, which shows the employment density in and around the GTHA. In green are the regions where there is a higher concentration of jobs than residents, and the areas in red have a higher concentration of residents than jobs.

Figure 1 Employment Concentration in the GTHA, 2016



The GTHA has grown by 860,000 people of all ages between 2006 and 2016, and the number of jobs in the region has increased by 250,000. This employment and residential growth has occurred in separate census subdivisions, as shown in Figure 2. Areas in which the number of jobs has increased relative to the number of residents are shown in red and those in which the number of residents has increased relative to the number of jobs are shown in green.

Figure 2 Change in number of jobs relative to residents by census division, 2006-2016



Given the geographical divide between workplaces and residential areas, commuting outside of municipal boundaries is necessary for almost half of people working in the GTHA. Figure 3 shows that outside of the cities of Toronto, Hamilton and Mississauga, fewer than 50% of people who live in each census subdivision (CSD) of the GTHA also work within the same municipal boundaries. In fact, the majority of employees in six of the nine municipalities in the GTHA with the highest number of jobs commute in from other municipalities, as shown in Figure 4.

Figure 3 Percentage of residents who live and work in the same census subdivision, 2016

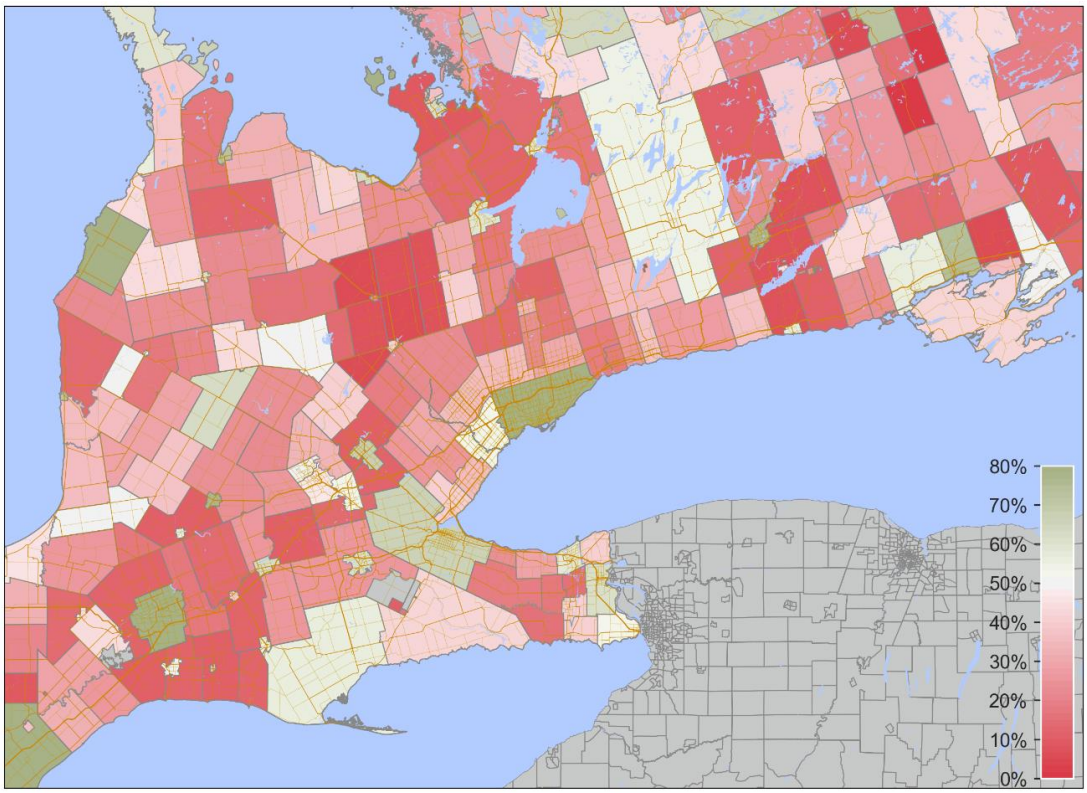


Figure 5 shows that in seven of the nine municipalities that have seen the greatest increases in employment between 2006 and 2016, most of the new jobs have been filled by residents living in other municipalities (Toronto and Markham are the exceptions). Each new job represents an additional commute, which puts pressure on the inter-city transportation infrastructure. This underscores the critical need for transportation infrastructure to keep up with residential and employment growth in the GTHA.

Figure 4 Percentage of locally employed people by place of residence, 2016

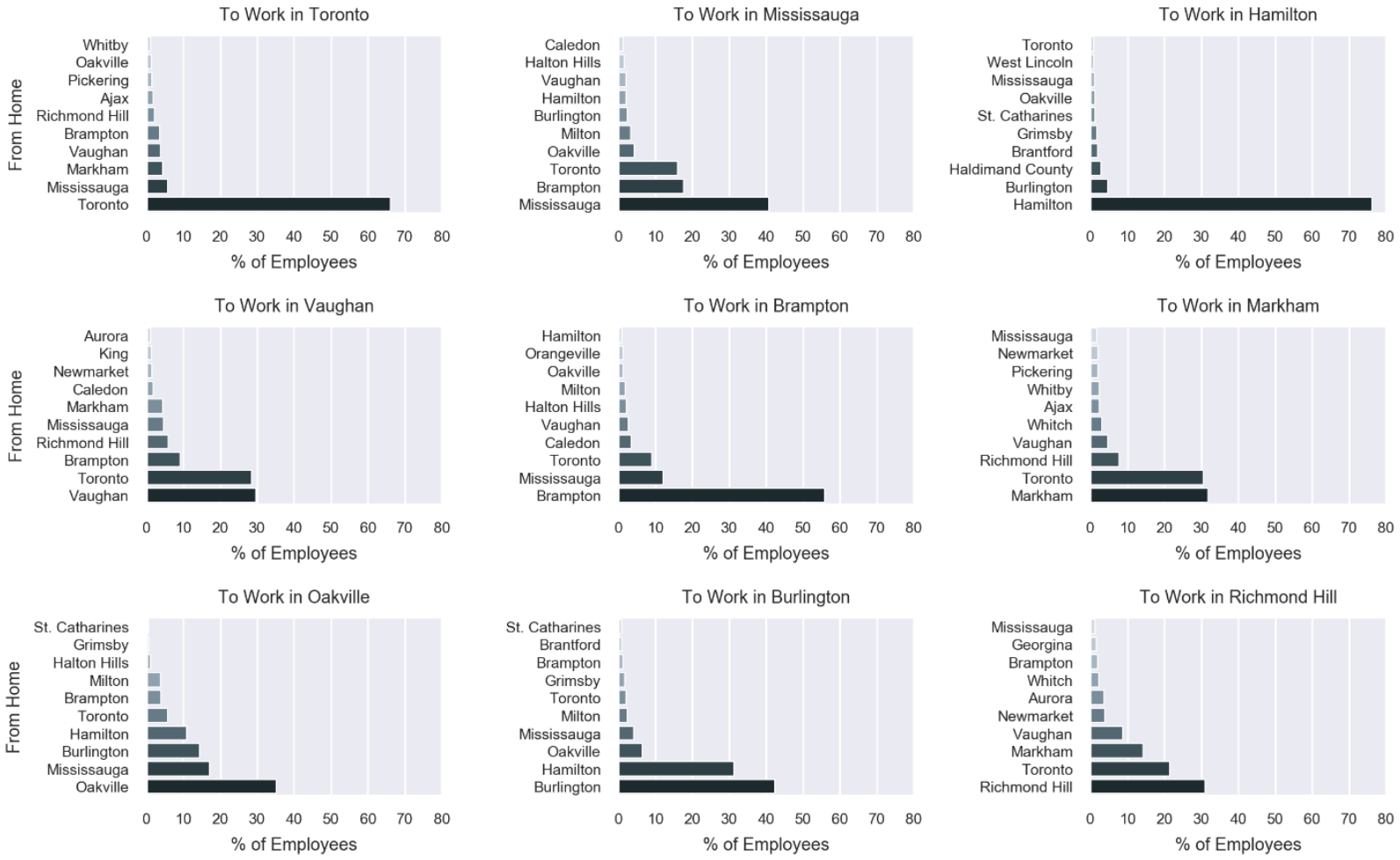
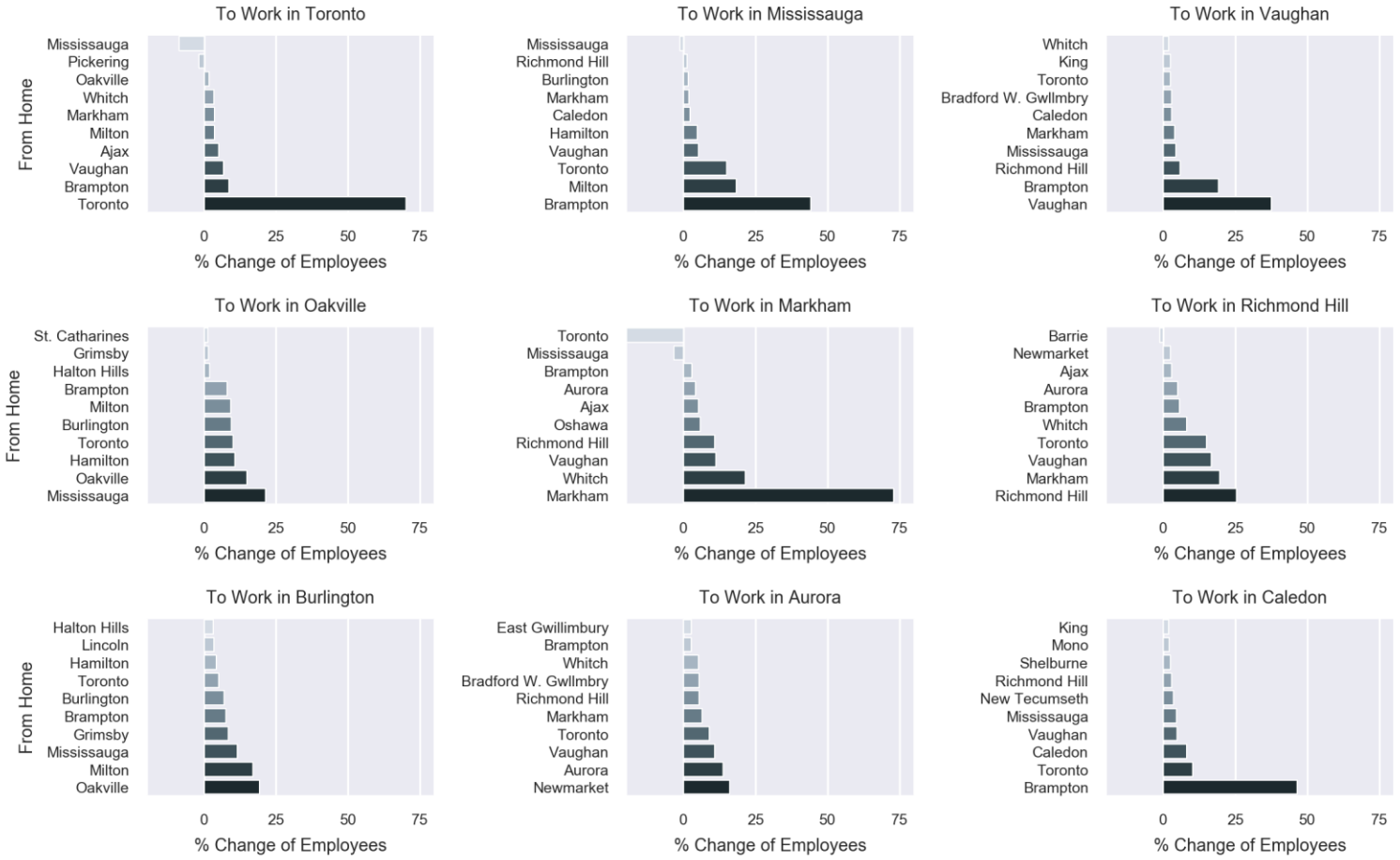


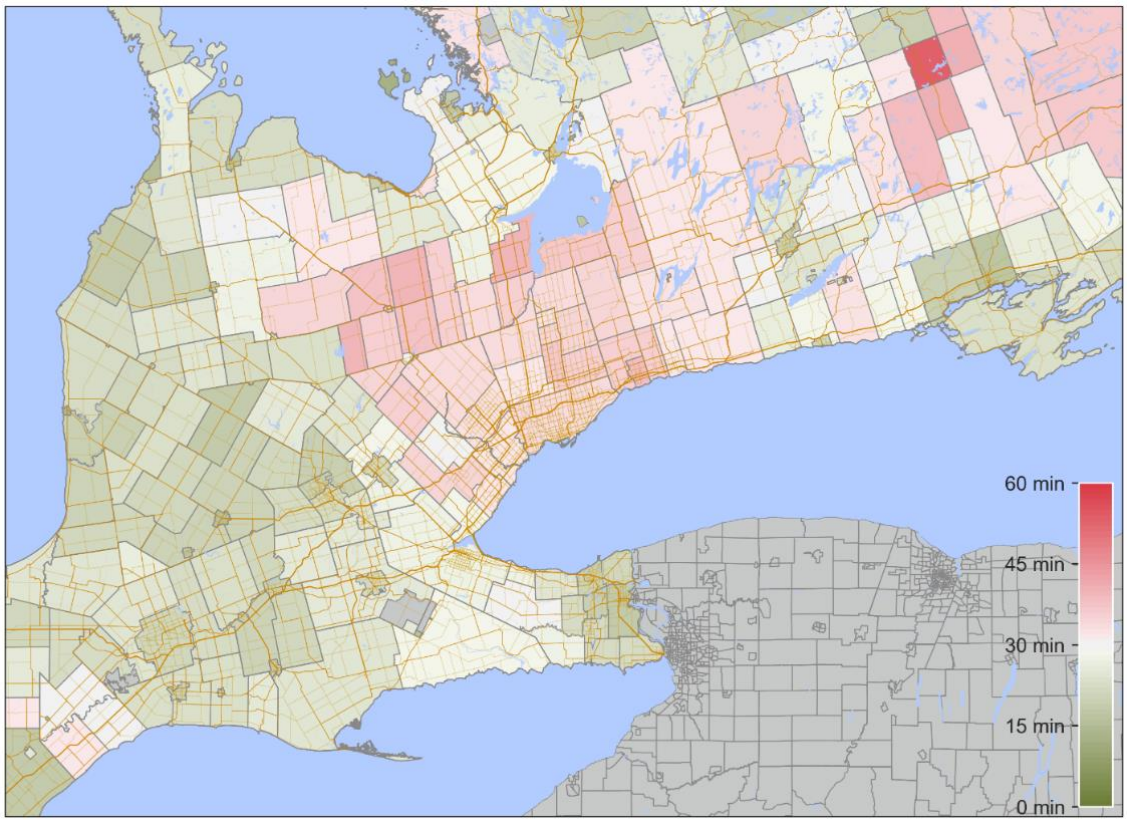
Figure 5 Change in percentage of locally employed people by place of residence, 2006-2016



2.2 Commuting Duration and Mode Choice

"Marchetti's constant", commonly cited in transportation literature, is the notion that cities develop such that the average person's commute time is 30 minutes in a single direction. However, in the GTHA, more than half of commuters (1.8 million people) travel in excess of 30 minutes to their place of work. Long commutes are a function of both the distance travelled and the congestion experienced on the transportation corridor used. As shown in Figure 6, residents of almost every census subdivision of the GTHA commute in excess of 30 minutes, on average. Census subdivisions located north of Toronto tend to have the longest commutes, some of which are in excess of one hour in each direction.

Figure 6 Average commuting duration (single direction) by origin, 2016



While the average commute exceeds 30 minutes for commuters in the GTHA across all modes of transportation[1], commuters for whom public transit is the main mode have some of the longest commutes across the population (see Figure 7).[2] In fact, among public transit commuters in the GTHA, commutes

[1] These data are taken from the Transportation Tomorrow Survey, which defines the main mode of transportation as the mode used for the leg of the journey lasting the longest.

[2] Note that people with longer commutes might prefer to take public transportation rather than drive private vehicles, which could mean that this difference between private vehicle and public transit commutes partially due to a selection effect.

lasting an hour or more are twice as common as commutes of 30 minutes or less. Nowhere in the GTHA is this the case for private vehicle commuters, as shown in Figure 9 and Figure 10.

Figure 7 Average duration of public transit commutes by origin, 2016

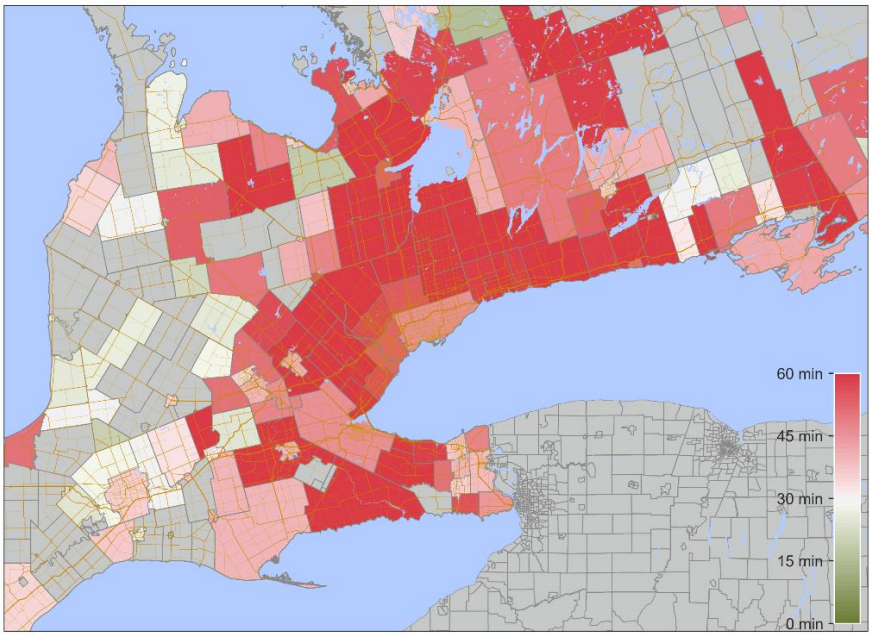


Figure 8 Average duration of private vehicle commutes by origin, 2016

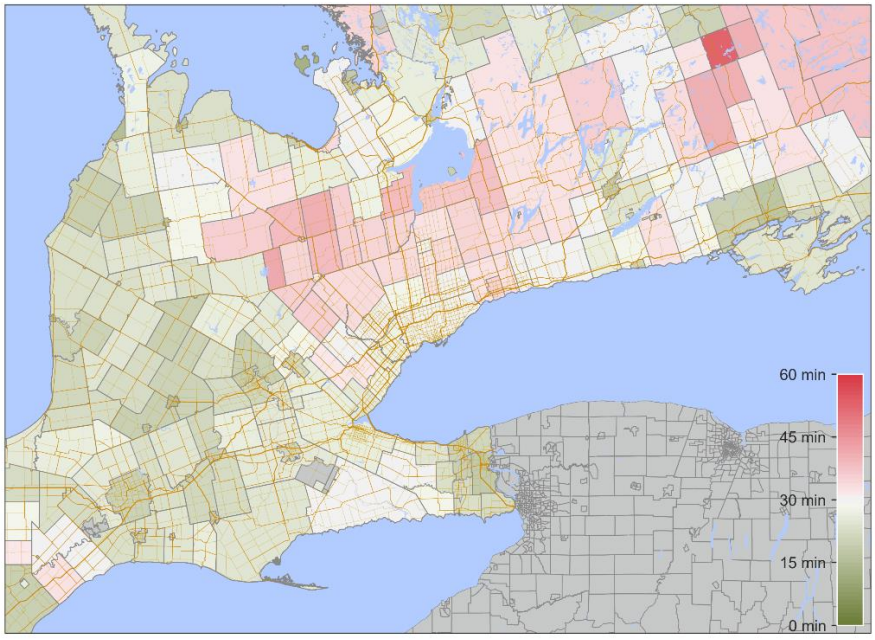


Figure 9 Ratio of public transit commutes of 60 minutes or more to 30 minutes or less, 2016

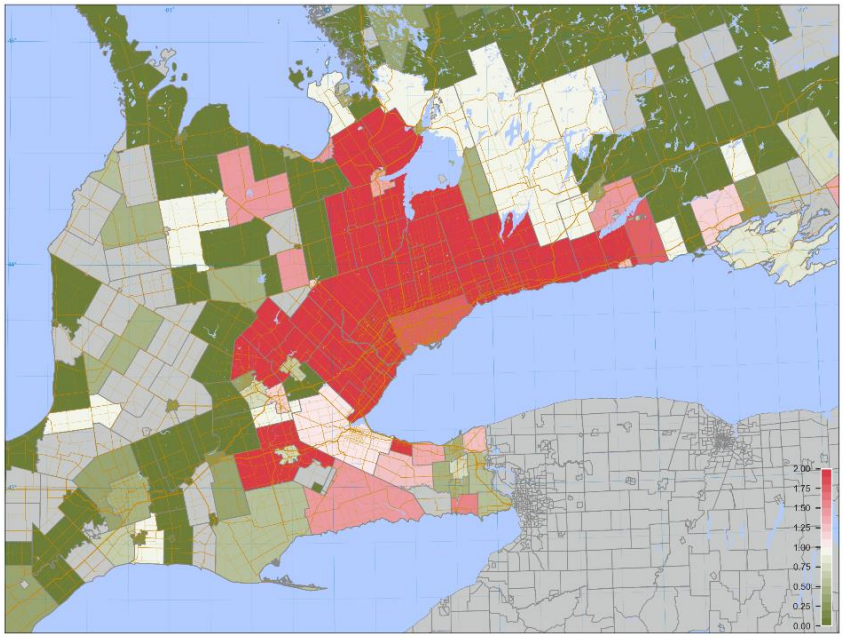
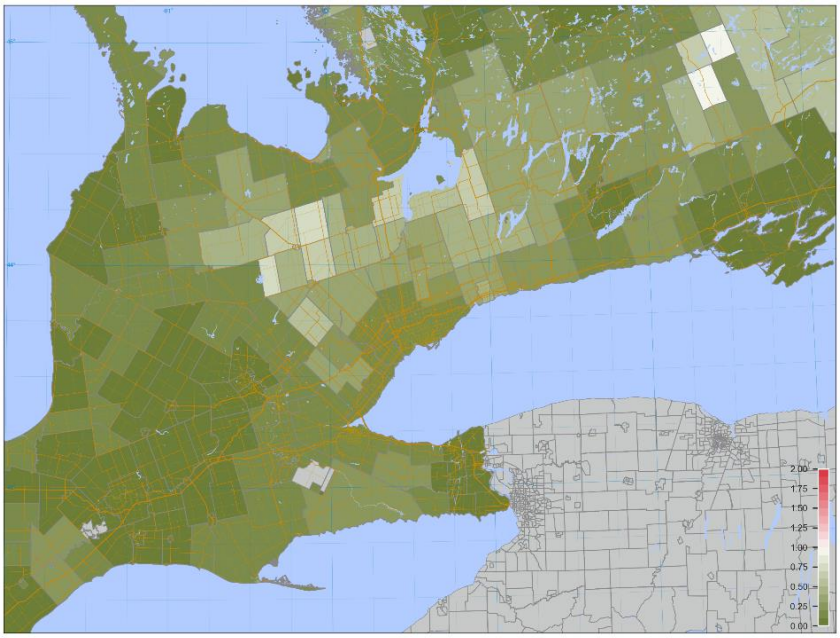


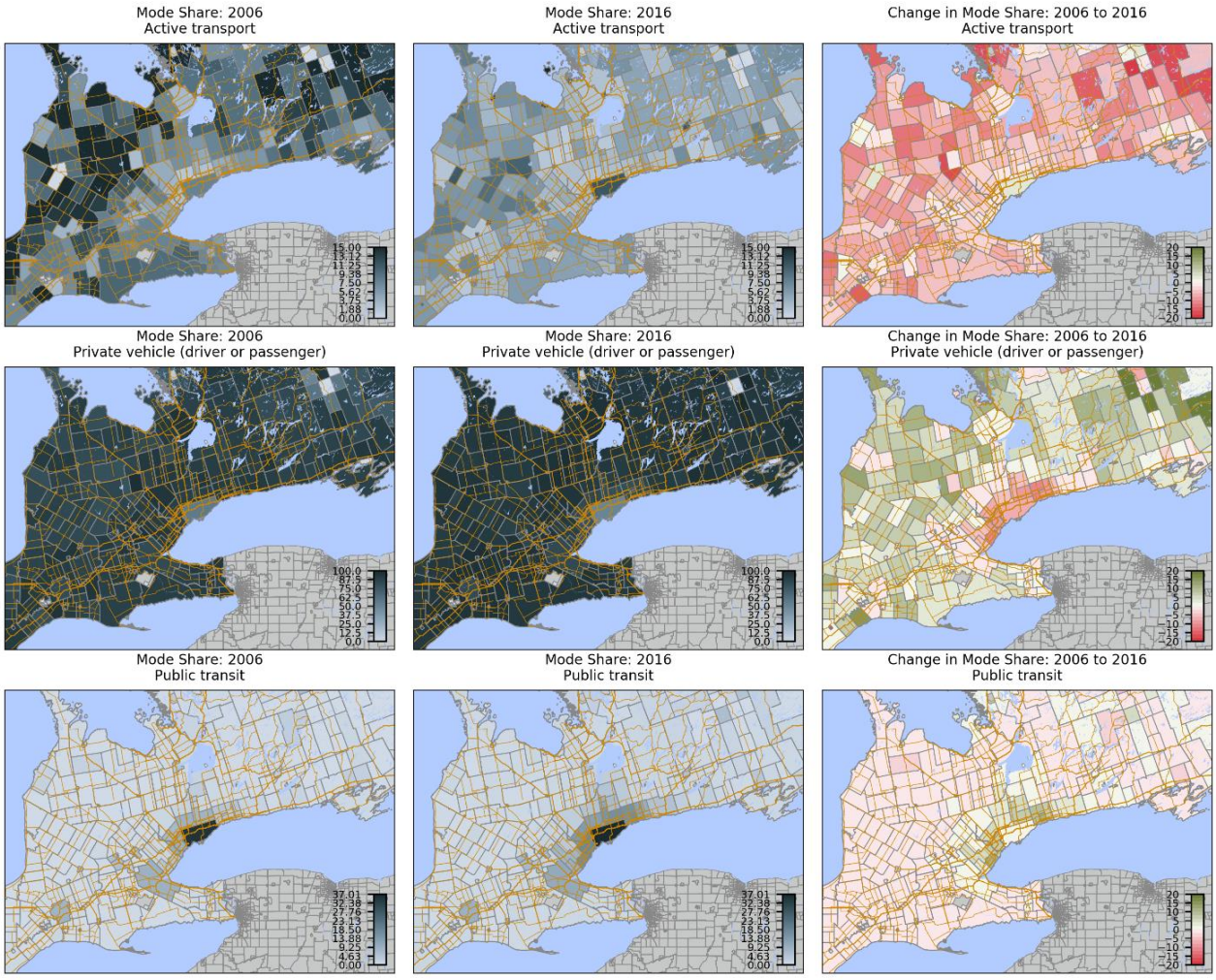
Figure 10 Ratio of private vehicle commutes of 60 minutes or more to 30 minutes or less, 2016



A commuter's chosen mode of transportation depends largely on the area in which they live. Commuters in Toronto tend to have the largest selection of modes of transportation since many residents can choose between active modes of transportation such as biking and walking, public transit (GO, UP express and TTC), vehicle-on-demand (VOD) services (e.g., taxis, Uber or Lyft) or commuting by car. In the rest of the GTHA, access to public transportation varies.

Outside of Toronto's urban core, the fraction of commuters using public transit as their main mode of transportation is small, as can be seen in Figure 11. Therefore, while the prevalence of public transit has increased as the main mode of commute for people residing in the GTHA, the share of private vehicle commutes has increased in the rest of the region.

Figure 11 Change in mode share by mode type, 2006 to 2016



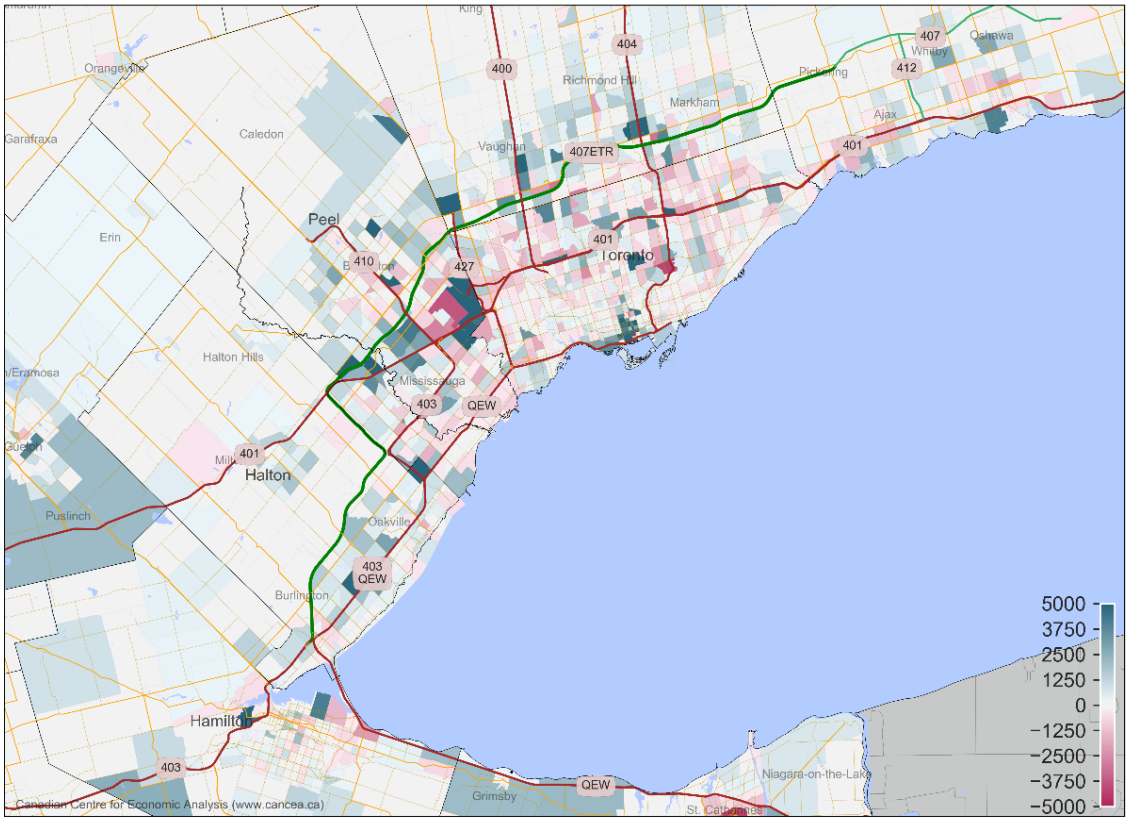
2.3 Close-Up on the Greater Toronto Area

2.3.1 Background

Most job and residential growth in the region has occurred in the Greater Toronto Area, which comprises the City of Toronto and the regions of Durham, York, Peel and Halton. Over half of Ontario's total GDP is generated within the Toronto CMA, which is almost entirely contained within the Greater Toronto Area. Provincial prosperity is therefore tightly linked to the GTA's economic success.

Distinct patterns of employment and residential concentration occurred between 2006 and 2016, as shown in Figure 12. The density of jobs has significantly increased in Toronto's small downtown dissemination areas and along the Yonge-University subway line.[3] This is the major high-density employment area of the region. Other employment areas can be seen in green in the figure, and considering their size, are lower-density, "edge city" types of employment areas that are accessible primarily by private vehicle. Meanwhile, lower-density residential areas have grown along Highway 401 and the Queen Elizabeth Way. Low residential and employment density are a challenge to the development of alternative types of transportation infrastructure outside of Toronto, namely public transit, which requires economies of scale.

Figure 12 Change in number of jobs relative to residents by dissemination area, 2001-2016



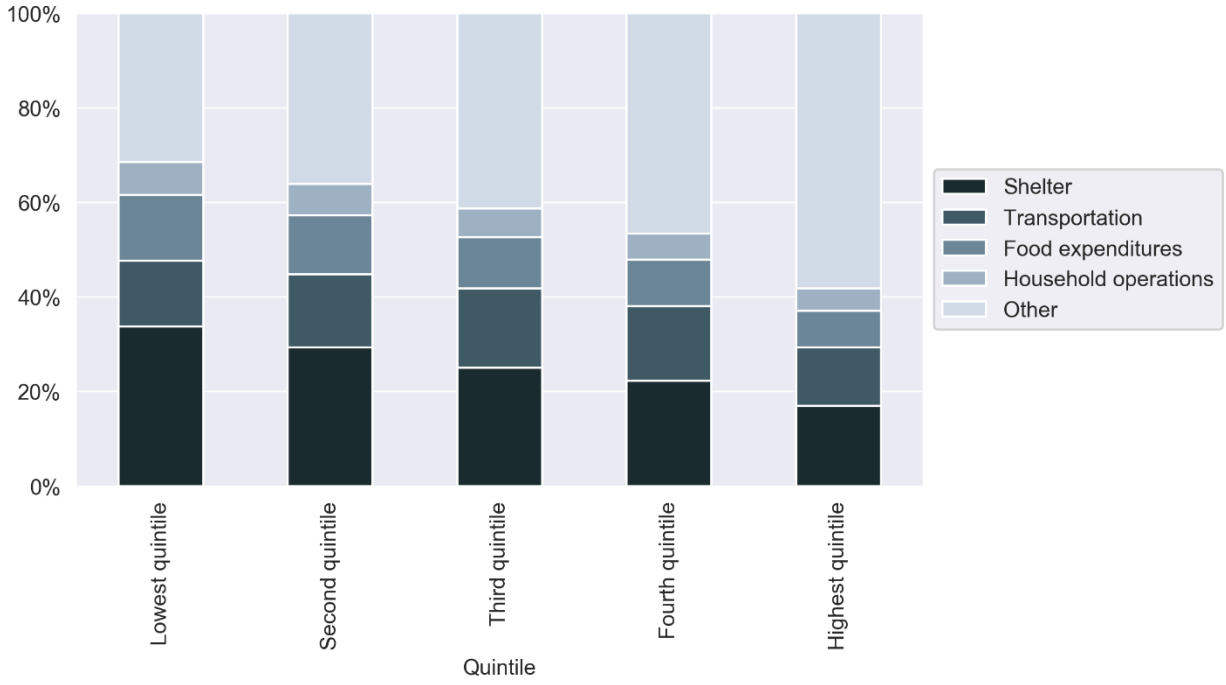
2.3.2 COSTS OF COMMUTING IN THE GTA

Transportation is a considerable component of the total expenditures of households of all incomes, but especially for households in the lowest income brackets. Housing and transportation together comprise almost half of all expenditures for households in the Toronto CMA whose before-tax incomes are in the bottom 20% of the population, as shown in Figure 13. On average, these households spend as much on transportation as they do on food. For low-income households, transportation and housing expenses are

[3] Dissemination areas are drawn to be somewhat uniform in terms of population size, targeted to be between 400 to 700 persons. Dissemination areas with a smaller land area are therefore much more densely populated.

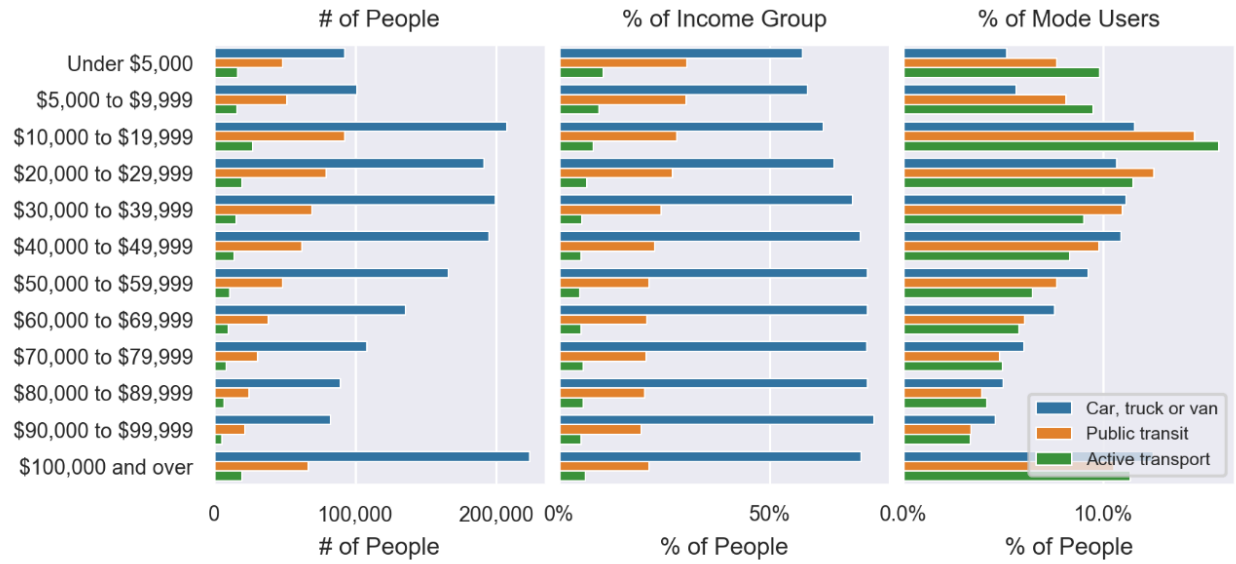
closely linked. To illustrate, a low-income family who can no longer afford to pay rent may have to move to a neighbourhood further from the wage-earner's workplace that has poor connections to public transit to find a dwelling within its budget. The amount spent on car maintenance and gas would then increase, in part offsetting the rent savings.

Figure 13 Household expenditure categories by income quintile, 2016



A household's transportation costs depend in large part on the main mode of transportation used for commuting. In the GTA, commuting by private vehicle is significantly more expensive than any other option (Deloitte, 2016), since associated costs include gas, parking, car insurance, and maintenance in addition to the cost of the vehicle itself. Despite the relatively high costs, households of all income levels rely heavily on private vehicles for commuting, as shown in Figure 14. The convenience and flexibility of driving is a large factor explaining this reliance on private vehicles – public transit takes longer per kilometre travelled and on average, will cost commuters 15 additional minutes per direction (Deloitte, 2016). The difference can be significantly larger for people living or working in neighbourhoods and areas with fewer connections to public transit.

Figure 14 Main mode of commute by individual income, Toronto CMA, 2016



In addition to the direct costs associated with transportation, commuters and the rest of the population collectively bear the costs of congestion. Congestion occurs when transportation infrastructure is at or above capacity. Past the point of capacity, every commuter's use of roads, trains, subways, etc. imposes a cost on the entire system in the form of congestion. These costs generally include longer trip times, slower speeds for everyone on the system and increased queuing, as well as increased air pollution in the case of road congestion. Congestion costs private vehicle commuters an additional 840,000 hours on the road per day, with an associated economic cost of $4.9 billion annually in the GTA alone (TomTom, 2018). Most of this cost is borne by the 1.8 million drivers who travel more than 30 minutes each way.

Excessive congestion can negatively impact the regional labour market and economic growth. It can increase the cost of doing business for local businesses, thus diminishing their ability to invest and discouraging them from growing their operations locally. In extreme cases, excessive congestion could cause businesses to relocate, potentially decreasing the local demand for labour. Congestion can also affect the supply of labour. Workers, facing a declining quality of life as a result of long, gridlocked commutes may choose to leave the area, and this could also discourage people from searching for work in the region if economic conditions are comparable elsewhere. Through its impacts on investment and labour market dynamism, congestion can impact regional prosperity and long-term economic development.

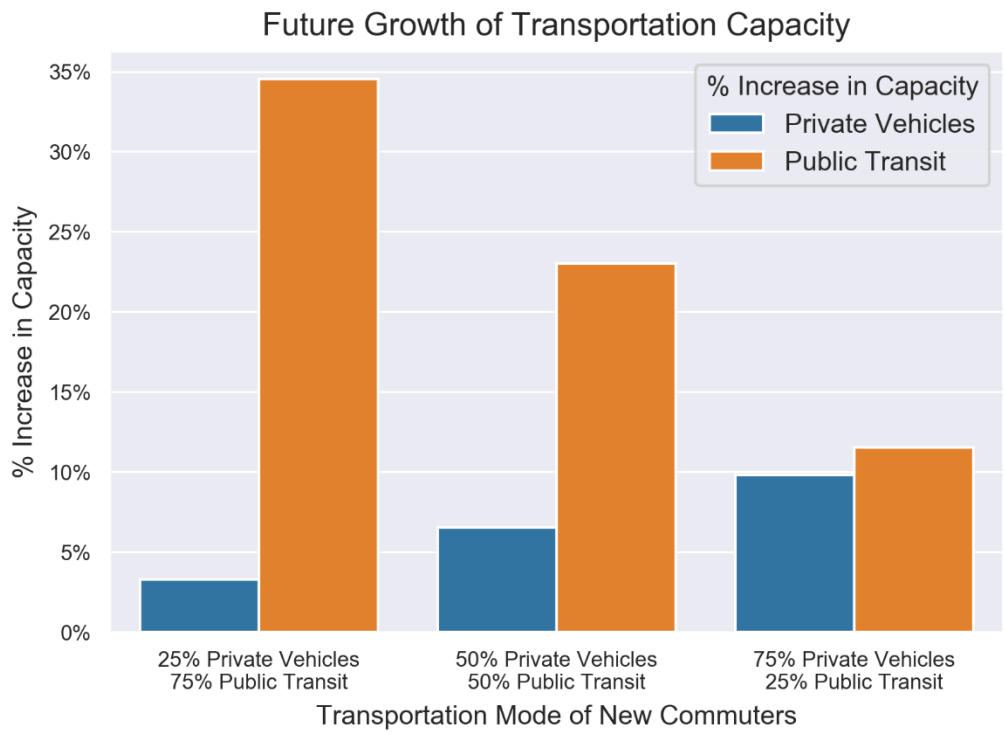
3.0 THE FUTURE OF COMMUTING IN THE GTHA

3.1 FROM NOW TO 2031

The GTHA is expected to continue to grow in the coming decades to a projected 10.1 million residents by 2041. The region must, therefore, be ready for the consequent increase in commuters using its transportation infrastructure. If the number of commuters Ontario continues to grow with the labour force, there would be over 620,000 additional daily trips from home to work, 12% more than today. Of these trips, 480,000 would be commuters who work in the GTHA, which is a 17% increase over the current number of commuters.

Figure 15 shows the percentage by which current capacity will need to increase to accommodate the additional trips projected for 2031, depending on the share of new commuters using private vehicles or public transit. Relative to current levels, public transit capacity will have to expand faster than road capacity, even if 75% of the new commuters choose to drive. The more people shift towards commuting via public transit, the more capacity will be required for public transit infrastructure. Given the significant costs associated with creating new transportation infrastructure or expanding and increasing the capacity of existing infrastructure, ensuring the productivity of these investments (i.e. maximizing the capacity per dollar invested) is critical.

Figure 15 Required increase in transportation capacity, 2016-2031



3.2 Planning for Growth

Transportation infrastructure bridges the gap between the places where people live and where they work. As shown in section 2.1, people increasingly work and live in separate municipalities within the GTHA. Even within municipalities, employment and residential areas are geographically distinct. There are currently a number of projects underway within the GTHA that would increase transit capacity for commuters travelling across the region (inter-municipally) and within municipalities (intra-municipally).

Ongoing and upcoming road infrastructure projects in the GTHA include:

- The eastward expansion of Highway 407 with connections to Highway 401, which is currently under construction.
- The addition of a new "GTA Northwest Corridor" running from Vaughan through Caledon and Brampton and ending in Halton, which would become Highway 413. This project does not yet have an estimated date of completion.
- Ongoing improvements to Highways 7, 400, 401, 403, 404, 410, 427 and the QEW.[4]

In addition to highways, inter-municipal transportation infrastructure includes the network of GO trains and busses. Expansions to the network are currently underway as the GO network prepares for a doubling of ridership (Metrolinx, 2008). This expansion involves:

- Increasing the frequency of service.
- Increasing the speed and efficiency of the fleet of GO trains.
- Electrifying the system.

Inter-municipal transportation can also be facilitated for commuters by initiatives that reduce the costs of travelling across multiple regional transit systems. The adoption of the PRESTO card system by 10 regional transit agencies within the GTHA has made it easier for commuters who live and work in different municipalities to pay for transportation. Fare integration programs, such as the discount applied to commuters travelling on the GO and TTC network on a single trip,[5] can further reduce the costs of commuting across municipalities using public transit.

Notable intra-municipal transportation infrastructure projects include multiple light-rail transit systems that are planned or under construction across the GTHA. Within the next five years, two light rail transit lines are expected to be in operation in Toronto (the Eglinton Crosstown and Finch West LRTs), as well as one in the Region of Peel and one in Hamilton[6] (Kitts, 2018). A new subway line called the Ontario Line has also been proposed for Toronto and is currently in the planning stages. The effectiveness of these projects for meeting the increased demand for transit infrastructure over the coming decade will depend

[4] According to the Southern Highways Program 5-year investment plan published by the Ontario Ministry of Transportation in 2017. No 2018 or 2019 update has been published.
[5] The government of Ontario will be discontinuing funding for this initiative after March 2020, at which point the program is expected to come to an end.
[6] Cancelled by the Government of Ontario as of December 2019.

on the productivity of these investments. This requires considering transportation infrastructure not as independent but rather as integrated with other types of infrastructure.

Harmonizing land use and transportation planning is one way to ensure public transit investments are generating maximum benefits. Transportation-oriented development (TOD) is a concept that fits this purpose. TOD is characterized by mixed-use, medium- to high-density development that is pedestrian-oriented. As an example, the principles of TOD have been applied to the planned development of the Mimico GO Station. According to current designs, the station itself will be a mixed-use development, which could contain residential and retail spaces, and it will be accessible by foot, bicycle, public transit, and by those being dropped off by private vehicle, with limited underground parking space (GO Transit, 2019). The cost of the station will be shared between Metrolinx and private developers. Despite its advantages, TOD is not yet the norm in transit planning in the GTHA. Many recent Toronto Transit Commission subway stations have been built in areas in which no adjacent or above-ground development is possible (e.g. Pioneer Village).

3.3 Emerging Trends in Transportation

3.3.1 Vehicle-on-Demand Services

Transportation and commuting patterns are likely to evolve over the coming decades. As new transportation technologies are developed and scaled up, these could significantly alter how people move through the region. One such example is the rise of “vehicle-on-demand” (VOD) services in the last decade, which in addition to taxicabs, include technology-driven platforms such as Uber and Lyft. These may already be affecting the demand for transportation infrastructure in the region.

VOD services share the roads with buses, private vehicles and commercial vehicles and therefore influence congestion levels. Studies conducted in metropolitan areas in the USA show that VOD services are more likely to be used as a substitute for public transit or active transportation than for private vehicle use, leading to a 180% increase in driving on city streets (Schaller, 2018). This suggests that rather than limiting the number of cars on the road, VOD services reduce the number of cars sitting idle in garages and may increase congestion.

The impact of VOD services on the demand for public transit appears to be mixed. Cities and towns with small, less extensive public transit systems have seen a decline in ridership following the expansion of VOD services in the area, which suggests that these offer a competing service. On the other hand, cities with larger, more extensive public transit systems have seen a small increase in transit use following their introduction, which suggests that these services increase access to public transit or otherwise complement large-scale transit systems (Miller, et al., 2018). One reason may be that they help solve the “last mile” problem, i.e. the difficulty of transporting people from a transportation hub to their final destination (work or home, for example) when these are located in areas that have fewer network connections and are too far to reach on foot.

VOD services are widely forecasted to continue to grow (Schaller, 2018; Miller, et al., 2018). Monitoring the ways in which they change the demand for existing road and public transit infrastructure is therefore crucial in order for planners and decision-makers to create an environment where these services help fill gaps without overloading the system or reducing the viability of existing public transit infrastructure investments.

3.3.2 AUTONOMOUS VEHICLES

Looking further into the future, the autonomous vehicle is a technology that has the potential to significantly alter regional transportation and commuting patterns. Although partial automation is well underway, the technology enabling vehicles to operate fully autonomously has yet to mature. The perceived benefits of the widespread adoption of fully-automated autonomous vehicles (referred to as AVs moving forward) include cost efficiency due to lower operating costs, reduction in insurance costs, parking fees, etc.; increased safety from fewer collisions and reduced congestion from reduction in the space between vehicles, among others (Ticoll, 2015; Kloostra, 2017). However, circulation by empty vehicles and the new trips induced by the convenience of this new technology (e.g. by previously mobility-challenged populations) could also increase the use of road infrastructure and increase congestion (Kloostra, 2017).

The precise ways in which AVs will affect the demand for transportation infrastructure in the GTHA are as of yet unclear and will depend on the rules governing their adoption and the ways in which the system will be set up. For instance, if AVs are mainly privately owned and permitted to drive without passengers and act as VODs when not in use by the owner, it is more likely that they will increase road congestion. However, if they are integrated into transit systems, they could help reduce the last-mile problem and play a complementary role, rendering public transit investments more productive.

3.3.3 TELECOMMUTING

While VOD services and AVs may affect transportation infrastructure by changing the supply of trips, employment trends have the potential to affect their demand. Daily commuters who travel to work in the morning and back home in the early evening make up the bulk of trips on any given weekday. In the GTA, 65% of these commuters drive private vehicles. Increasingly sophisticated and low-cost telecommunications technologies now make it easier than ever for people to work from outside the traditional office setting. This corresponds to a change in work culture; workers are increasingly given the flexibility to come in at alternative hours and work from home, and many people do not even have a traditional office to go to (Deloitte, 2016). A deepening of this trend, in conjunction with demographic shifts that will see many traditionally employed workers reaching retirement age, could significantly alter the demand for peak-hour transportation. These trends deserve close monitoring to enable existing transportation infrastructure to be adapted to changing conditions.

4.0 CONCLUSIONS

The GTHA is a region that continues to be shaped by transportation trends. Commutes exceeding half an hour in each direction have become the norm in the region, as people travel further for work and congestion is persistent. While more costly than public transit, most people in the region continue to rely heavily on private vehicles for commuting. This may be due to the flexibility and convenience offered by driving and the fact that commuters on public transit experience higher commute times than drivers on average.

As the region continues to grow, additional commuters put pressure on existing transportation infrastructure, which is causing congestion to worsen. Congestion and lengthy commute times increase the cost of doing business and decrease the quality of life in the region. This can have long-term effects on the regional economy and put the region's future prosperity at risk. Mitigating these risks requires ensuring that there will be sufficient, properly leveraged and well-planned transportation infrastructure in the coming decades.

This study highlights the importance of focusing on the productivity of transportation investments and of jointly considering transportation and land-use planning and economic policy. As transportation trends develop, such as the expansion of vehicle-on-demand services or the emergence of autonomous vehicle technology, their effects on existing road and transit capacity will also have to be monitored. Given the constraints on land and public funds, it is critical that every business case for regional transportation investments consider the productivity of that investment. Aligning residential, economic and transportation development planning is critical to Ontario's prosperity and future growth.

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DATA SOURCES

Key data sources used in the analysis include:

- **98-400-X2016325**: Commuting Flow from Geography of Residence to Geography of Work: - Census Subdivisions: Sex (3) for the Employed Labour Force Aged 15 Years and Over Having a Usual Place of Work, in Private Households, 2016 Census - 25% Sample Data, Statistics Canada
- **97-561-XCB2006011**: Commuting Flow Census Subdivisions: Sex (3) for the Employed Labour Force 15 Years and Over Having a Usual Place of Work of Census Subdivisions, Flows Greater than or Equal to 20, 2006 Census - 20% Sample Data, Statistics Canada
- **98-400-X2016324**: Main Mode of Commuting (10), Commuting Duration (7), Time Leaving for Work (7), Sex (3) and Age (5) for the Employed Labour Force Aged 15 Years and Over Having a Usual Place of Work or No Fixed Workplace Address, in Private Households of Canada, Provinces and Territories, Census Divisions and Census Subdivisions, 2016 Census - 25% Sample Data, Statistics Canada
- **97-561-XCB2006013**: Mode of Transportation (9), Industry - North American Industry Classification System 2002 (21), Occupation - National Occupational Classification for Statistics 2006 (11), Work Activity in 2005 (4) and Sex (3) for the Employed Labour Force 15 Years and Over Having a Usual Place of Work of Canada, Provinces, Territories, Census Divisions and Census Subdivisions of Work, 2006 Census - 20% Sample Data, Statistics Canada
- **98-400-X2016329**: Commuting Destination (5), Main Mode of Commuting (10), Sex (3) and Age (5) for the Employed Labour Force Aged 15 Years and Over Having a Usual Place of Work, in Private Households of Canada, Provinces and Territories, Census Divisions and Census Subdivisions, 2016 Census - 25% Sample Data, Statistics Canada
- **98-400-X2016332**: Main Mode of Commuting (10), Employment Income Groups (18), Sex (3) and Age (5) for the Employed Labour Force Aged 15 Years and Over Having a Usual Place of Work or No Fixed Workplace Address, in Private Households of Canada, Provinces and Territories, Census Metropolitan Areas and Census Agglomerations, 2016 Census - 25% Sample Data, Statistics Canada
- **11-10-0223**: Household spending by household income quintile, Canada, regions and provinces
- **97-561-XCB2006010**: Commuting Distance (km) (9), Age Groups (9) and Sex (3) for the Employed Labour Force 15 Years and Over Having a Usual Place of Work of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census - 20% Sample Data, Statistics Canada
- **98-400-X2016326**: Main Mode of Commuting (20), Commuting Duration (6), Distance from Home to Work (12), Time Leaving for Work (7), Sex (3) and Age (5) for the Employed Labour Force Aged 15 Years and Over Having a Usual Place of Work, in Private Households of Canada, Provinces and Territories, Census Metropolitan Areas and Census Agglomerations, 2016 Census - 25% Sample Data, Statistics Canada
- **98-400-X2016328**: Main Mode of Commuting (10), Commuting Duration (6), Distance from Home to Work (12) and Time Leaving for Work (7) for the Employed Labour Force Aged 15 Years and

Over Having a Usual Place of Work, in Private Households of Canada, Provinces and Territories, Census Divisions and Census Subdivisions, 2016 Census - 25% Sample Data, Statistics Canada

- **Census Profile 2016 (DA)**: Census Profile - Age, Sex, Type of Dwelling, Families, Households, Marital Status, Language, Income, Immigration and Ethnocultural Diversity, Housing, Aboriginal Peoples, Education, Labour, Journey to Work, Mobility and Migration, and Language of Work for Canada, Provinces and Territories, Census Divisions, Census Subdivisions and Dissemination Areas, 2016 Census, Statistics Canada

Additional data processing and alignment was performed by CANCEA to reconcile inconsistencies among the datasets and over changing geographies.