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Cars, Congestion and Costs: A New Approach to Evaluating Government Infrastructure Investment

Current studies underestimate the costs of congestion in Canada's major cities, with a focus on time lost in traffic. Governments also need to include the wider economic benefits that are foregone because of urban congestion.

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The Study In Brief

The existing debate about the cost of traffic congestion in Canadian cities has been limited to estimating the value of time lost by people sitting in traffic. However, there are broader costs of congestion that should be taken into account. This *Commentary* offers a decision-making framework for governments seeking to include these broader, social welfare costs in selecting which infrastructure investments merit public subsidy, and which ones should be handled by the private sector.

In general, the social returns from infrastructure can be substantial and governments are missing a large portion of the economic benefits of infrastructure when they do not estimate them. In particular, economic externalities – which arise when an individual's use of infrastructure affects someone else – can be quite large. Governments should assess the full range of social costs and benefits of externalities and include them in building a consistent economic case for investment.

With regard to transportation in particular, this report provides a new way of estimating the cost of congestion. To date, governments have made the case for transportation investment based on the estimated economic cost of time lost due to congestion. In the Greater Toronto and Hamilton Area, the commonly used estimate is that congestion costs the economy about $6 billion per year.

However, the existing studies provide underestimates of the costs of congestion. The reason: they ignore the positive effects of relationships among firms and people that are among the main benefits of urban living. These urban agglomeration benefits range from people accessing jobs that better match their skills, sharing knowledge face-to-face, and creating demand for more business, entertainment and cultural opportunities which, in turn, benefit other people. When congestion makes urban interactions too costly to pursue, these benefits are foregone, adding significantly to the net costs of congestion. For the Greater Toronto and Hamilton Area this report estimates the additional costs to be at least $1.5 billion and as much as $5 billion per year.

For Canadian governments, the framework for comparing the private and social returns of investments can apply to a wide range of investments, ranging from transportation to education to health and much more. In cases in which there is a substantial private return, the economically efficient option is for pure private provision. With such a framework in hand, Canadian governments can make better choices about their investment needs.

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Governments of all levels across Canada are facing pressure to invest in the nation's infrastructure. However, they also have limited budgets with which to invest and conflicting demands for the money.

It is essential that they know which projects are most worthy of public funding and which ones should be left in private hands entirely. Transportation infrastructure to address traffic congestion is a prominent case in point where funding choices must be made. With the province of Ontario, for example, planning on spending $35 billion on infrastructure over the next three years, it is important that policymakers know how best to allocate that spending across many potential projects. To determine the investment projects that are most worthwhile, governments should determine which projects maximize social returns and pursue them.

Yet, governments often do not seek to account for all the social costs and benefits of infrastructure projects, partly because they are often difficult to quantify. This *Commentary* shows that the social returns from infrastructure can be substantial and that governments are missing a large portion of the economic benefits of infrastructure when they do not include them in their cos-benefit evaluations. In particular, economic externalities – which arise when an individual's use of infrastructure affects someone else – can be quite large. Governments should assess the full range of social costs and benefits of externalities and include them in building a consistent economic case for investment.

A New Way of Estimating the Cost of Congestion

To date, governments have made the case for transportation investment based on the estimated economic cost of congestion. In the Greater Toronto and Hamilton Area (GTHA), the commonly used estimate is that congestion costs the economy about $6 billion per year. Such estimates are based mainly on an assumption of the value of time people spend commuting on congested thoroughfares.

However, existing estimates of the economic cost of congestion are underestimates – and, furthermore, are potentially flawed estimates. The reason: they ignore the positive effects of relationships among firms and people – known as urban agglomeration externalities – that are among the main benefits of urban living. These range from accessing jobs that better match peoples' skills, sharing knowledge face-to-face, and creating demand for more business, entertainment and cultural opportunities which, in turn, benefit other people. When congestion makes urban interactions too costly to pursue, these benefits are foregone, adding significantly to the net costs of congestion. For the GTHA I estimate the additional costs to be at least $1.5 billion and as much as $5 billion per year in lost wages.

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A New Approach to Government Investment Decisions

It is time that governments took a new approach to infrastructure investment by taking into account the broader economic impacts. For example, governments should estimate the benefits of the relationships between people and firms in an urban area. A person riding a subway or using a road creates the demand for infrastructure that enables the existence of that subway or road for other people in his city – a positive externality. At the same time, that person using the subway or road is crowding out a part of the infrastructure's potential use by others – a negative externality.

Canadian governments should select infrastructure investment on the basis of two overarching principles:

1. Calculate the economic externalities of an investment, both positive and negative, and include measurable externality benefits in the cost-benefit analysis used in the initial decision to build; and

2. Charge users of infrastructure the full social costs, to the extent possible. In the case of transportation infrastructure, governments should charge users for the full cost of congestion, but invest in more infrastructure than would be self-sufficient from fare or toll revenue alone, with a view to increasing quantifiable benefits from urban agglomeration.

What Theory Says: The Optimal Level of Infrastructure Investment

Canadian governments of all levels face continuous pressure to build additional infrastructure, ranging from transportation to health and education infrastructure, and much more. How should governments prioritize their investments?

The basic principle of identifying the ideal quantity of production of standard goods or services – those without any externalities – is that producers supply consumers up to the point where the price consumers are willing to pay for one more unit of a good equates with their benefit from doing so. That is, the marginal cost must match the marginal benefit. If the price a consumer is willing to pay is more than the cost of production, the producer will find a way to produce more. However, in the presence of externalities, the private benefit of consumption does not match the wider social benefit of consumption. The benefits of a new road, for example, can extend far beyond reduced congestion for drivers to include increased business activity. Hence, a framework for quantifying externalities can apply to a wide range of potential investment decisions by an income-constrained government.

The best way to address externalities is for governments to make sure that people's private decisions to use infrastructure are influenced by pricing that takes into account the costs or benefits from a broader social and economic perspective.[1] When people do not take account of their effect on others, governments can step in to set pricing at levels that cover the social costs.

Negative versus Positive Externalities

Determining the optimal amount of government infrastructure investment and the appropriate price to charge for using that infrastructure hinges on externalities. Government policymakers should

1 The other approach economists might advocate is private ownership, allowing parties to negotiate to address the effect of an externality. Such a solution is clearly not feasible for many types of externalities, such as pollution into the atmosphere (although potentially useful for other types of more geographically limited pollution). Transaction costs of many individuals negotiating directly over access rights for roads, for example, make this implausible as a solution.

weigh the negative externalities, such as those caused by traffic congestion, against the positive externalities, such as those associated with enhanced urban access.

To provide one example, traffic congestion is a negative externality in which one person's decision to drive harms others. When a driver enters a roadway, his decision is based on the private cost (such as his time and vehicle operating costs) to himself of using that road. He does not take into account that his choice may preclude others from using that road or slows down traffic. Likewise, other drivers on the road impose the same cost on him, sometimes resulting in congestion. The same principle applies to other infrastructure, such as transit, when a train, subway or bus user does not consider the effect on others of his riding at peak times. Congestion pricing, in general, imposes a cost on each user equal to the cost that user imposes on others. Commuters will choose to use the road or subway up to the point at which the last user's willingness to pay equals the cost to himself and to others.

On the other hand, a positive externality is a benefit that accrues to others from an individual's decision. A classic example is the decision of a person to plant flowers in his lawn. The person who plants the flowers benefits from a nice-looking yard, but so do his neighbours who enjoy a nicer looking neighborhood.[2]

A Framework for Infrastructure Investment Decisions

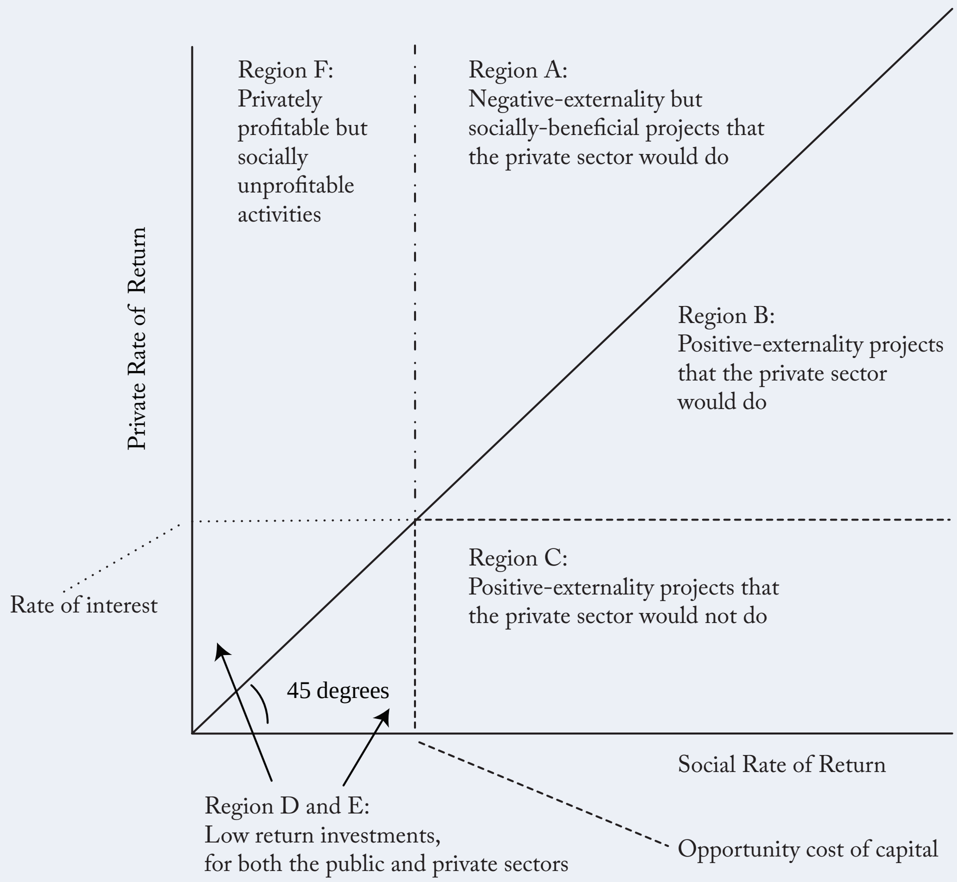
In the absence of externalities, the private rate of return of an investment is the deciding factor. Projects attract private investment dollars if the rate of return exceeds the prevailing private interest rate at which businesses can borrow. However, government investment often involves projects in which there is an insufficient private rate of return to enable private investment. For pure public goods, such as open-access parks, the environment or national defence, the private returns will be insufficient to incent private investment. However, the broader social returns may be quite large. How can policymakers directly compare varying projects with differing degrees of private and social returns because of the presence of externalities?

Warner (2013) provides a graphical framework for analyzing investments and setting investment decision rules in the presence of quantifiable externalities (Figure 1). On the vertical axis is a private rate of return, and the horizontal axis is a social rate of return. The minimum threshold of investment on the vertical axis is the prevailing private rate of interest: its corollary on the horizontal axis of social cost is the opportunity cost of other worthwhile investments foregone. Projects in which there is a positive (negative) externality are on the right (left) side of the 45 degree line.

The framework in Figure 1 points to a number of potential decision rules for government investment – either for individual projects, or for a portfolio of connected investments. First, when projects are analyzed as individual investment decisions, the government should not support projects that do not exceed the opportunity cost of investment. The money can be better spent elsewhere. Second, it should not support projects in which the private rate of return exceeds the prevailing private interest rate. Leave them to the private sector.

2 An example of how to internalize these benefits comes through neighborhood or business improvement areas that are group agreements of local members to invest in local beautification and other improvements. However, the incentive for individuals to not become members and act as 'free riders' when membership is voluntary highlights the externality of this benefit.

Figure 1: Social and Private Rates of Return on Investment



Source: Warner (2013).

These two rules limit the government's investment window to projects in region C in Figure 1. Although there will be some projects in which the private rate of return is lower than the social rate of return, both are positive (region B of Figure 1). The private sector will still make the investment in such a project – barring the existence of other regulations that are barriers to private investment – thus making public investment unnecessary. Similarly, projects in which the private returns are high, but social returns are negative, are best addressed with private investment, but with government taxation of the negative externality to equate public and private returns.

A third decision rule is that governments should initially select projects that generate the greatest positive social returns – those furthest to the right side of the horizontal axis of positive social returns in Figure 1. This rule allows for a number of potential approaches to such investment. A first approach is for the government to subsidize the private provision of such infrastructure and increases the private rate of return such that it now exceeds the hurdle private interest rate.[3] A second approach is for direct government provision when doing so costs less than subsidizing private provision. The decision framework suggests governments choose one of these two routes for projects and select projects that provide the largest social returns but are not sustainable on user fees alone.

Yet, the decision to raise public funds to finance a project creates negative externalities due to the economic harm of taxation. How much economic damage raising revenues causes depends on the specific type of tax used. The negative effect of taxation requires that governments calculate the marginal cost of funds for every dollar of revenue raised to finance a project. Once all potential projects have been assessed based on these externalities, governments can select the projects to subsidize or finance entirely. However, as the government funding envelope for infrastructure investment expands, and more tax revenue is needed to finance infrastructure investment, the economic damage increases, pushing otherwise socially worthwhile projects further left on the horizontal axis of Figure 1.

This decision framework requires that governments quantify the net values of externalities – positive and negative – of investments. However, investments are only one means of addressing externalities. A better approach to take, when possible, is setting taxes or fees to equate private returns with social returns.[4] In aggregate, the 'optimal' level of infrastructure investment is when all projects that fit within region C in Figure 1 are undertaken.

The decision framework presented in Figure 1 is relatively simple. The difficulty in applying the framework in practice comes in estimating the social and private rates of return and externalities. Some approaches, such as by Gu and Macdonald (2009), look at the aggregate effect of public investment on private-sector productivity and find a small, but important, positive effect that could form a starting point. Others, such as Aschauer (1989) find a highly positive effect of public infrastructure investment on aggregate productivity. However, governments will likely need to look at externalities applied to specific projects, rather than aggregate returns of public infrastructure, to assist in specific investment decisions (see Box 1 for examples).

Who Should Pay? and How Much?

When users pay the full cost of infrastructure, they equate private rates of return with social rates of return: that is, user fees have no externality cost on the rest of the economy. For all public investments, taxes cover the difference between user charges and costs. Raising taxes imposes a cost on the overall economy, lowering the social rate of return. This is the marginal cost of public funds.[5] When a government raises an additional dollar of revenue through taxes to finance an infrastructure project – whether through income tax, fuel taxes, a consumption tax or any other tax not directly related to the use of infrastructure – it affects the

3 In this context, subsidization includes contracted services and public-private partnerships in which governments do not provide all financing capital, only the amount that enables companies to earn at least the prevailing rate of return. With sufficient competition for government subsidies, this will minimize the amount of public subsidy required to enable private investment.

4 The alternative approach is to set the maximum quantity of a good sold, provide permits for people to use a service, and allow people or firms to buy and sell permits among themselves. This is similar to a cap-and-trade program, and is common for addressing pollution externalities.

5 See Dahlby and Ferede (2011) for an overview and calculation of these amounts by province.

Box 1: The Big Picture: Externalities for Other Infrastructure Investments

Education: There is a relatively large body of literature that shows that there are substantial private returns to education (see Card 1999 and, for Canadian evidence, Boothby and Drewes 2010). That is, people with additional education earn a higher income. However, there are broader social benefits of education that justify public subsidy of education. The most conclusive studies suggest that the social return is between 1 and 3 percent for an additional year of education and no more than 5 to 6 percent (Acemoglu and Angrist 2000). Full government provision of free education crowds out the potential private education that could be self-supporting through user fees. The lesson from this is that public policy interventions should deal with the challenge of selection bias and aim not to reward people for actions they would have taken anyway regardless of the existence of government supports. However, the difficulty in using externalities in justifying an expansion of education infrastructure is disentangling the benefit due to infrastructure as opposed to education services, although the two are necessary complements.

Healthcare: As with education, healthcare provides a number of private and wider societal benefits. There may be some externalities in the provision of inoculation services in which people who do not get a vaccine benefit from others who do (see Ward forthcoming for an example). However, in the context of government infrastructure investment, it is unclear whether publicly provided services are superior to privately provided services on the grounds of externalities. A number of economic justifications for government intervention in healthcare are motivated by market failures other than externalities. For example, moral hazard or adverse selection issues make government intervention in health insurance markets economically sensible (see Poterba 1996). However, applied to healthcare infrastructure investments, ignoring potential regulatory and legal restrictions that limit private investment, this provides a strong case for private investment in healthcare with the ultimate buyer of many health services being the government.

International and interregional transportation infrastructure: The externalities involved with transportation that facilitates longer distance travel than within an urban area will be different. For example, evidence elsewhere shows the agglomeration benefits dissipate beyond 80 kilometres (see Rice et al. 2006), meaning that urban agglomeration benefits do not apply to all types of infrastructure. However, other externalities such as the effect of induced competition, the scale economies of access to international markets, or technological spillovers from greater foreign openness, may justify a government subsidizing transportation infrastructure that facilitates international trade.

Parks and environmental infrastructure: Although many types of recreational infrastructure can, and should, be financed through user fees, some investments in parks and environmental protection cannot. Governments can ascertain the social rate of return on these investments by surveying individual willingness to pay – using proper methods of contingent valuation (see Carson 2011 for the scope of work in this field). The aggregate social demand for a non-priced public good is the aggregate individual demand. The efficient amount of such a good is the amount at which aggregate marginal willingness to pay is equal to the marginal cost of providing that good. However, contingent valuation of willingness to pay is fraught with numerous challenges, such as defining the relevant market, survey design, the lack of incentive for individuals to provide their true willingness to pay, and much more.

decision making of a firm or a person. This is an economic harm, since, for example, a firm may put off hiring decisions or, a consumer, spending decisions. The marginal cost of funds measures the change in economic behaviour due to government raising additional revenue and varies by the type of tax used, with corporate income taxes having the highest cost and consumption taxes having the lowest cost (Dahlby 2009).

When negative externalities can be fully incorporated into the private rate of return of infrastructure, such as through congestion tolls, the optimal last investment project offers a return just above the prevailing interest rate. Under reasonable assumptions, the price to users that includes externalities would raise sufficient revenue to cover the cost of provision of transportation infrastructure (Lindsey 2012). That is, the infrastructure would be self-financing. All else constant, if the forecast revenue from a price fully incorporating externalities is above (below) forecast cost, then the provider should expand (contract) capacity.[6]

However, addressing a negative externality will lower the private return, which may in turn lead to actions that improve the private return but reduce broader social gains.[7] Applied to transportation, if the government over-invested at the outset and financed that extra cost from tax revenues, then the economic cost would be a lower social rate of return because of the economic harm caused by raising taxes (the marginal cost of public funds). On the other hand, if governments chose instead to charge lower tolls to reduce the monetary cost of access to a wider economic catchment area, then it would result in a lower social rate of return through excess congestion.[8]

Assessing the Externalities of Investments in Transportation Infrastructure

If governments choose to apply the above framework to transportation infrastructure – which can range from new transit, to new roads to improvements to existing facilities – there are many specific types of externalities that benefit firms and people. Governments can accentuate them with additional transportation infrastructure while limiting the negative consequences of urban co-location. The evidence from Canada and around the world shows that greater urbanization is a key factor behind higher incomes.

The Example of Urban Agglomeration and Congestion

The idea of urban agglomeration combines two economic concepts: scale economies and externalities. Scale economies arise as a benefit, to firms or people, that increases with the quantity of production or output. Urban scale economies are externalities when costs to a firm decrease or

6 More precisely, governments should be determining this in a net present value calculation of future costs and revenues from an investment. Lindsey and de Palma (2013) find that having correct estimates of initial demand as part of a cost-benefit analysis is the largest determinant of whether a road, for example, will be self-financing.

7 Arnott (2007) presents this dilemma as follows, as applied to transportation infrastructure: “If more travel generates more non-market interaction, then the small reduction in the toll below the Pigouvian level generates a first-order welfare gain with respect to non-market interaction and only a second-order welfare loss with respect to congestion.”

8 The economics literature is now at a stage in which it is possible to model the relative tradeoff between congestion externalities and agglomeration externalities. See Brinkman (2013) for details on how to implement a comparison of externality costs and benefits of a transportation improvement.

benefits increase as its surrounding market becomes larger because of the location decisions of others.[9]

The benefits of urban living hinge on the relationships between people and firms. As more people live in a city or region, other people already in that area benefit. Jane Jacobs (1969) first showed the importance of firms in one industry benefiting from the proximity of firms in another industry. As well, agglomeration economies have been the subject of a large body of recent academic literature (see Rosenthal and Strange 2003 for a further discussion). The benefits of co-location drive urban life. Natural advantages – such as the location of natural resources – only explain about 20 percent of the reasons why people locate in proximity to each other (Ellison and Glaeser 1999).

The Benefits of Urban Proximity

There are a number of potential reasons for the externality benefits of urban proximity. They are:

Labour Market Pooling: A larger labour market can benefit both firms and people. A larger labour market can enable a better match of a person's skills and interests to the specific needs of an employer. This allows greater specialization of employees, resulting in increased economic efficiency and growth (Duranton and Jayet 2011). A second benefit is that a larger labour market can reduce risks for both employees and firms, allowing them to be less dependent on their existing relationships. Overman and Puga (2010) find that spatial concentration allows firms with volatile output to ramp up production by hiring from a deep labour market while also allowing workers to reduce their risk of being reliant on transitory work from a single firm.

Learning in Cities: Knowledge dissemination is most effective in close proximity – as Marshall (1890) put it, having ideas 'in the air' is akin to a public good. An example of this is that a given patent is more likely to be cited by another patent from the same city (Rosenthal and Strange 2003). The evidence shows that workers in big cities do not have higher initial ability than workers in small cities but that, after controlling for innate worker ability, the wages of workers increase upon moving. Workers accumulate more valuable experience in larger cities, leading to higher incomes (de la Roca and Puga 2012).

Competition in Cities: Increased competition creates an incentive for firms to innovate in order to beat their competitors – an idea known as 'creative destruction' (for a discussion of 'Schumpeterian growth,' see Howitt 2007). High transportation costs raise barriers to entry in potential new markets and could affect the extent of competition. The evidence shows that higher firm productivity results from more productive firms reaping the benefits of urban density; but not by weak firms being more likely to exit from larger, and presumably more competitive, markets (Combes et al. 2012).

Cooperation in Cities: An additional benefit of urban agglomeration may be that firms – and people – can share inputs such as infrastructure, supplier networks or other services. Holmes (1999) finds that firms in areas with more nearby employees in the same industry source their inputs from more nearby areas compared to firms in the same industry elsewhere.[10]

9 Note that the concept of urban scale economies is different from that of industry-specific clusters, which Behrens (2013) finds has relatively little effect on manufacturing wages when controlling for the spatial distribution of the aggregate Canadian manufacturing sector.

10 Brown and Rigby (2013) find that, using Canadian data, this effect is especially pronounced for larger and older firms, relative to younger, smaller firms.

Consumer Cities: Cities also provide cultural and consumer amenities – arts and sports venues, for example – that would otherwise not be cost-effective in areas with less population. Cities also offer greater selection of social and romantic partners than less dense areas, allowing for better matching akin to labour market pooling. Natural amenities, such as scenery or temperature, also drive individual location decisions to some extent.[11] Glaeser et al. (2001) find that locations with otherwise lower transportation times to amenities – because of either better public transit or urban layouts that enable car travel – have experienced greater demand than parts of cities distant from consumption centres. Denser city cores also have a greater variety of consumption opportunities than outlying areas, which Couture (2012) finds results in significant welfare gains of hundreds of dollars per year for consumers residing in the downtown area of large cities.

The Costs of Urban Proximity

Although there are many benefits associated with urban scale, there are costs as well that can result in decreasing returns to urban scale: transportation congestion and housing costs.

Transportation Congestion: Without any congestion, city size would be constrained by the technical limits of speed and time – the speed at which it is safe to transport people over a time period considered to be a worthwhile commute. Congestion, however, results when demand for transportation infrastructure outstrips the available supply.

Housing: Combes, Duranton and Gobillon (2012) find that urban costs of living due to agglomeration are modest. The evidence suggests that, on the margin, people are indifferent to which city they live in. However, the cost of urban land will be artificially higher if restrictions on development constrain the extent to which builders can increase supply to meet demand. In the absence of zoning restrictions, housing costs would approximately follow the cost of purchasing urban land and building additional floors. However, in cities with restrictive zoning, costs for additional housing exceed the marginal cost of urban land and additional floors (Glaeser, Gyourko, and Saks 2003).[12]

The Effect of Urban Agglomeration on Neighbouring Regions

Agglomeration can boost incomes in urban regions. But what is the effect of greater agglomeration on neighbouring non-urban areas? Economies of scale are the starting point for analyzing economic activities unevenly distributed between a region with a large population (the core) and a less populated one (the periphery).[13]

For example, if transportation costs between regions are substantial, a firm seeking to serve

11 Glaeser et al. (2001) find that climate had been the single most important driver of county-level house prices and population growth in the US from 1980 through 2000. Vancouver and Toronto, despite being cold relative to the rest of the world, offer some of the most temperate climates of all locations in Canada, perhaps driving growth there.

12 In the United Kingdom, where there are stricter land-use regulations than in the US or Canada, medium-sized, economically struggling cities have office rents more than 40 percent higher than in Manhattan despite having lower construction costs (Cheshire and Hilber 2008).

13 This analysis is founded on Krugman (1991a,b). This work – which formed the basis of an economics literature known as 'New Economic Geography' – contrasts with the trade literature that focuses on comparative advantage as the basis of trade.

both markets will choose to set up facilities in both regions. However, if transportation costs fall sufficiently, firms may find it more profitable to locate all productions to the region with the largest population and ship to the peripheral region, reducing total costs. These lower total costs in the larger market result in higher real wages there, which further entice workers to migrate from the periphery to the core. Despite the allocation of economic activity now being unequal across locations, the people in the example are better off by migrating to the larger region and earning higher real wages there. Transportation investments focused on urban areas can improve incomes in aggregate, albeit at the cost of people leaving peripheral regions to seek higher wages in core regions.

However, at some point the costs of living in the core – such as transportation congestion or higher housing prices – offset the scale benefits. Excess congestion could result in an outcome in which workers tend to locate in two regions – one large, one smaller – or two mid-sized regions. The scale of the most-populous region would be constrained by the cost of living and real incomes would be lower than otherwise. (Combes, Duranton, and Overman 2005). In other words, the cost of congestion reduces aggregate real incomes by constraining the agglomeration benefits.

Agglomeration-enhancing investments in larger areas where agglomeration economies are potentially larger will prove more economically worthwhile than in less populous regions. Further, if people move from smaller cities, in which some agglomeration economies exist, to larger cities, the result is a lowering of agglomeration economies in the small area, but an increase in the large areas. Because more people benefit in the larger area, this loss of agglomeration from people leaving the lower-population area still results in higher aggregate incomes. When migration is involved in any estimates of agglomeration, it is important to deduct lost agglomeration economies so as to prevent double counting of benefits.

The Evidence of Agglomeration Benefits

Taking all above positive externality effects together, what is the total effect of urban agglomeration on incomes?

The Evidence from Around the World

Empirical studies from around the world have found that doubling the size of an urban area tends to increase incomes there by between 3 and 8 percent (Rosenthal and Strange 2003). However, it is not immediately clear whether larger populations result in people earning higher incomes, or whether people with higher incomes tend to locate in areas with higher populations. In order to test which way the causality runs, a number of studies (Ciccone and Hall 1996 and Combes et al. 2010) find that by looking at cities that are large for some historical reason – such as soil quality, which may have driven urban growth long ago – larger populations result in higher incomes, and not vice-versa.[14]

The Evidence from Canada

Does the international evidence hold in Canada? I test the extent of agglomeration at three

14 They do this using what are known as instrumental variable techniques. This approach deals with the potential issue in which a factor that researchers cannot control for is correlated with both urban size and incomes. After using instrumental variables to isolate a factor that determines urban size, but not incomes, these studies show that the causality predominantly runs from larger city size to higher incomes, and not vice versa.

geographical levels: at an aggregate level of Census Metropolitan Areas (CMAs), Census Tracts, and Census Subdivisions.[15] This builds on previous work by Beckstead et al. (2010), a rare example of other work that assesses the scale of agglomeration economies in Canada, which found that individuals living in regions with large populations have wages about 3 to 5 percent higher than people in regions with smaller populations, approximately on the same scale as that elsewhere in the world.[16]

CMA-level Agglomeration Benefits: The largest Canadian CMAs have average annual after-tax family incomes approximately $40,000 higher than the smallest CMAs in Canada (Figure 2). CMA population alone explains slightly less than 40 percent of the difference in incomes between CMAs.[17] How much of this relationship is due to agglomeration, and not other possible confounding factors? After controlling for the inherent characteristics of the population of a CMA – such as education levels, and the province the CMA is predominantly located in, I find that doubling the population of a CMA results in a 3.6 percent increase in nominal incomes (Table 1).[18] My estimate is in line with international evidence showing a similar magnitude of relationship between city size and incomes.[19]

Census Tract-level Agglomeration Benefits: How does access to more people within urban areas affect incomes? I take every Canadian Census Tract and calculate the size of the labour force in concentric circles 50 kilometres around the centre of that Census Tract. I find that as the population surrounding a tract doubles, the average family income in that Tract increases by 1.3 percent (Table 1).

Census Subdivision-level Agglomeration Benefits: A similar pattern holds when looking at Ontario Census Subdivisions (Figure 3). As the population within the 50 kilometres area surrounding a Census Subdivision doubles, the incomes of people living in that Census Subdivision increase by 2.6 percent, and doubling own-Census Subdivision population increases incomes by 4.3 percent.

15 Census Tracts are small areas with between 2,500 and 8,000 residents and located in CMAs. Census Subdivisions are statistical units approximately equal to lower-tier and single-tier municipalities, First Nations reserves, and rural unincorporated areas. Census Metropolitan Areas are statistical boundaries that Statistics Canada uses to define effective labour markets with a total population of at least 100,000. More specifically, Statistics Canada designates Census Subdivisions as part of a CMA by whether at least 50 percent of commuters from that Census Subdivisions commute from the municipality to the core municipality in that CMA. For details, see http://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo009-eng.cfm.

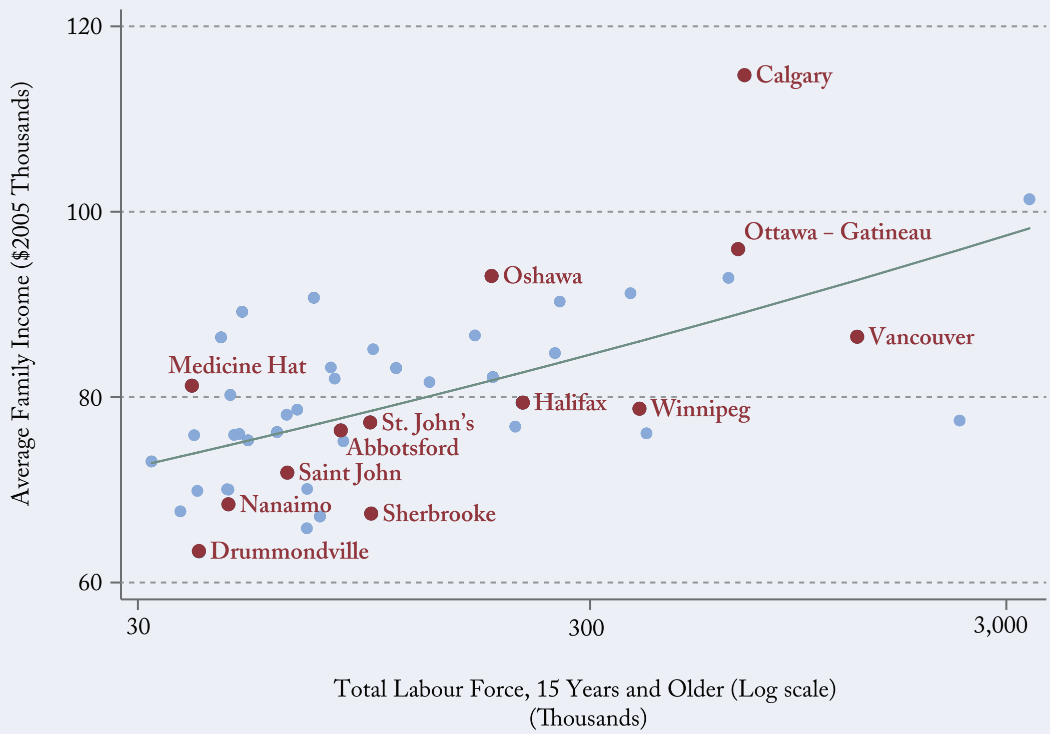
16 They also demonstrate the causality of this with an instrumental variable approach similar to that of international studies.

17 Specifically, this is taken from the r-squared of the regression from column three of Appendix Table A-1. Province-specific effects and the average education levels of people living in these CMAs explain a further 33 percent, which is similar to the findings from Beckstead et al. (2010) on how much human capital explains incomes. See Appendix for details.

18 I calculate this by taking the exponent of the coefficient of the elasticity of population size from column 4 in Table A-1. For a doubling of population size, I calculate this as $2^{0.0514}$. I do not estimate the effect of costs of living in response to urban size.

19 Given the findings in a number of previous studies elsewhere that this causal interpretation is valid, I do not test whether this relationship is potentially subject to reverse causality as the Canadian causality test has been done by Beckstead et al. (2010), and has shown the direction of causality to emanate from urban size.

Figure 2: Income and Size of Labour Force by Census Metropolitan Area, 2006 Census



Note: Line is predicted relationship between average family income and population.

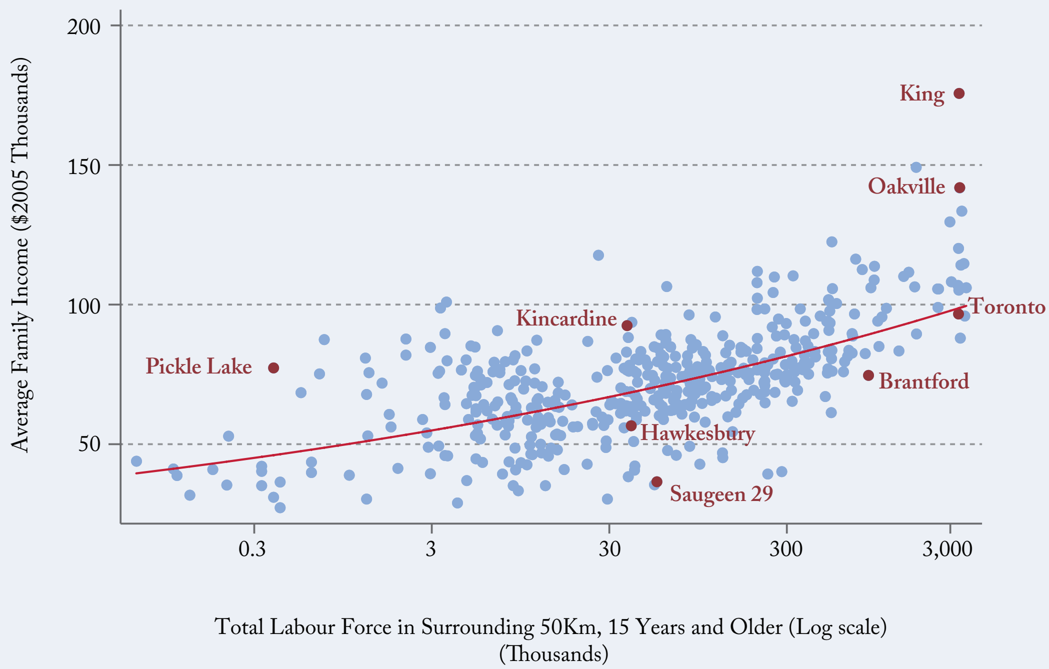
Source: Author's calculations from Statistics Canada.

Table 1: Effect on Average Family After-Tax Incomes of Doubling Labour Force Size

Overall CMA	Surrounding 50km Around Census Tract	Surrounding 50km Around Census Subdivision	Within Census Subdivision
percent increase in incomes			
3.6	1.3	2.6	4.3

Source: Author's calculations from Statistics Canada.

Figure 3: Income and Size of Surrounding Labour Force, Ontario Census Subdivisions, 2006 Census



Note: Line is predicted relationship between average family income and population.

Source: Author's calculations from Statistics Canada.

Quantifying the Cost of Urban Congestion

How can governments take externalities and apply them to calculate the costs and benefits of investment decisions? The current public debate around the economic cost of congestion is based on quantifying the cost of time lost in traffic (for example, see Toronto Board of Trade 2013). However, the existing estimates are potentially flawed and ignore the potential economic benefit that would arise from enabling broad positive agglomeration externalities.

The 'Optimal' Level of Congestion

In order to assess the cost of congestion, it is important that policymakers have an appropriate target for the optimal amount of congestion. Drivers would prefer roads with no traffic at all, ensuring no traffic congestion. However, the outcome would be an inefficient over-expansion of roadway. Increasing investment in roads to the point at which traffic flows freely, in the absence of any pricing, would result in a subsequent increase in demand to the point at which congestion would largely, but perhaps not entirely, return to the previous level (Duranton and Turner 2011). A free flow baseline is therefore only a reflection of road supply, not demand (Couture, Duranton and Turner 2012).

Existing studies of Canadian costs of congestion use a measure similar to the free flow estimate (Transport Canada 2006a). They compare actual traffic speed to an 'acceptable' level that is 60 percent of the speed limit. They label a road as congested when the speed is below that measure (Wallis and Lupton 2013). An engineering definition of the optimal level of congestion takes the point at which the total flow through a road is maximized, and says that congestion occurs when demand for the road exceeds this capacity.[20] A cost of congestion based on the value of time lost should incorporate travel over a road network rather than a single road (see Couture, Duranton and Turner 2012).

Existing Studies of the Cost of Congestion in Canada

There are two frequently cited studies of the economic cost of congestion in Canadian cities. In the first, Transport Canada (2006a, 2006b) calculates the economic cost in major Canadian cities from longer travel times and the additional cost of less reliable travel times requiring people to include contingency time in their travel.[21] Transport Canada calculated the total economic cost of congestion by multiplying the amount of time that commuters and other drivers lost due to congestion by the assumed value those travelers placed on their time. These costs amount to, in 2002 dollars, $2.5 billion in the Greater Toronto and Hamilton Area – or $473 per person – and $5.2 billion overall in Canada's five largest cities per year (Lindsey 2009, cited in Dachis 2011).[22]

The second study of the economic cost of congestion, specific to the Greater Toronto and Hamilton Area (GTHA), was produced by Metrolinx (2008a), the regional transit body. This estimate provides two separate costs that sum to a total cost of congestion of $6 billion per year in 2006 dollars. The first cost of $3.3 billion is akin to that in the Transport Canada studies. The study estimates an additional $2.7 billion per year in costs due to (i) increased transportation costs for businesses and (ii) the need to pay workers higher wages to compensate for higher commuting costs, resulting in otherwise lower employment.[23]

A Broader Look at the Cost of Congestion

The above-cited studies form a starting point for estimating the costs of congestion. However, they ignore the broader, unrealized external benefits. The methodology I employ considers the economic costs that result when a resident of an urban area does not take advantage of the benefits of living there and congestion is to blame. That is, the unrealized economic gains from easier access to surrounding population are an economic cost that should be added to the total costs of congestion. I estimate these additional unrealized benefits using a simple economic model (Venables 2007) that shows the link between commuting costs, agglomeration benefits and income (see Box 2 for details).

20 See Dachis (2011) or Wallis and Lupton (2013) for a representation of this speed-flow diagram. A similar approach applies to other types of transportation infrastructure. In an analysis of New Zealand congestion costs, Wallis and Lupton (2013) find that the method used in Canadian studies overestimates the time-cost of congestion relative to the engineering definition of the cost of congestion by a factor of approximately two, but is less exaggerated a cost than if Canadian estimates had been based on a free flow level of traffic.

21 Other costs include additional greenhouse gas emissions as well as additional fuel consumption due to waiting in traffic. This congestion cost does not include the economic costs of delayed commercial vehicles or freight, or costs associated with automobile or public transit passengers, accidents, noise, road damage, distortions to driving behaviour, and off-peak period congestion.

22 The other four cities are Montreal ($1.4 billion in congestion costs), Vancouver ($0.9 billion), Calgary ($0.2 billion) and Ottawa-Gatineau ($0.2 billion).

23 The study also measures other indirect logistics costs, such as the need to maintain higher levels of inventories to buffer against higher delivery time variability.

Box 2: A Theoretical Model of Social Welfare and Income Benefits from a Reduction in Congestion

The basic premise of a stylized model is that people live in one of two areas: the first is an urban area in which residents have high paying jobs but incur commuting and housing costs in order to live in the city. The housing costs urban resident pay decline as they live further from the urban core – where all urban jobs are located – whereas their commuting cost increases in proportion to the distance they travel.

A second group of workers live and work outside the urban area in the periphery, where all jobs are lower paying than in the urban area but there are very low housing or commuting costs. Workers then sort themselves between urban and non-urban areas up to the point in which a worker will earn the same real wage including social welfare costs – that is, after taking into account commuting and housing costs.

What would happen if the cost of commuting fell? People within the existing urban area would see their commuting cost fall and people previously living and working outside the urban area would start commuting to the urban core. These new commuters now benefit from higher wages by switching to a high-wage job inside the urban area although they must now pay higher commuting and housing costs. If incomes in the city increased, in aggregate, with overall urban population, then the wages of both existing urban area-dwellers and new commuters would increase.

A numerical example helps explain this model: A worker residing and working in the periphery earns $120 a day after tax ($200 before tax). She has an alternative opportunity: to work in an urban area for $144 a day after tax ($240 before tax). However, if the additional monetary commuting costs of reaching the new job are $12 and inconvenience costs (such as tolerating crowds) and time value are an extra $14 a day, she would value the urban area job at $118 a day (144–26), and prefer her current job. If a transport improvement reduced her commuting costs by $4 a day (an increase in her productivity at her job in the urban area would have the same result), what is the gain to her income and welfare? If she took the job in the city, her real wage would increase by $16 by earning $24 more per day but paying only $8 in commuting costs. However, if the commute takes the same amount of time or is the same level of inconvenience, which she values at $14, her welfare gain is $2 per day, meaning she will slightly be better off by taking the urban area job. Her increase in income is $40 because of the increase in pre-tax salary. A road toll (or transit improvement) that increased the commuting cost by, say, $2 from the original scenario, but reduced the time cost or inconvenience value of her commute by $6, would have the same net result of an increase in her welfare and income.

The Effect of Increased Tax Revenue

An additional consideration in assessing the benefits of investing in transportation infrastructure that increases agglomeration is the effect of higher incomes on government tax revenue. As workers move from lower-wage jobs to higher-wage jobs, government income tax revenues increase. Workers make their job decisions based on net-of-tax returns to commuting to cities, making the effect on government revenues an externality, but one that does not affect economic growth as this is a transfer of income.

Using the same numerical example as above, tax revenues increase by $16 by this worker choosing a job that pays her a higher wage. She does not take into account the effect of her decision on tax revenues because she makes choices based on after-tax utility. This makes the tax revenue implications of her decision a further externality in infrastructure decisions.

Source: Adapted from Venables (2007) and DFT (2005).

Counting the Cost of Unrealized Gains

To calculate the economic cost of congestion due to foregone agglomeration economies, I calculate the effect of a transportation investment program that reduces commuting times in line with the expected average time savings from Metrolinx's proposed investment strategy.[24] Following the methodology of the United Kingdom Department for Transport (herein referred to as DFT, 2005, which applies to a large transportation investment in a major metropolis), I calculate the total economic benefits of transportation improvements as the sum of the following components, and their subsequent effect on government income tax revenues:

1. the agglomeration benefits to workers currently living and working in the urban area who become more productive by being surrounded by more people;
2. the increase in the labour force participation rate of potential workers in the urban area because of lower commuting costs; and
3. the benefits to workers who switch from lower wage jobs outside of urban areas and commute to higher wage jobs in the urban area.

Separating Social Welfare and GDP Costs of Congestion

The above economic benefits differ in that some are social welfare-enhancing benefits that also result in higher incomes, while others leave overall social welfare the same even though they increase incomes. The first component listed above results in an improvement in both social welfare and gross domestic product (GDP). Further, using the framework from Figure 1, these are the only economic benefits of transportation infrastructure that are externalities and should be part of the social rate of return of a new investment.

The second and third components result in increases in measurable GDP, but not social welfare. The benefits of higher incomes come largely as a tradeoff for longer commuting times that workers now take on to access a higher paying job. The increase in commuting time reflects the findings of Duranton and Turner (2011) that people respond to lower costs of travel through increased capacity by increasing their travel consumption up to the point where net welfare is the same.

Benefit 1: The Agglomeration Benefits for Existing Urban Residents

Currently employed workers in an urban area would benefit from reduced congestion by having access to parts of the urban area currently too distant to reach because of congestion. The total agglomeration benefit for people in each Census Tract is the product of the following elements:

- the percentage increase in surrounding population – specifically, the labour force above the age of 15 – for which transportation improvement enables access;[25]
- the average individual employment income of people in that Tract; and

24 The forecasted effect is that the planned investment program will reduce average Greater Toronto and Hamilton Area commuting times from a forecast 109 minutes in 2033, if it were to make no investments, to 77 minutes. Metrolinx (2008b) further estimates that by 2031 the average commute length will increase from 15.2 to 17.5 km. Metrolinx (2008a) estimates that the investment plan will reduce the monetary and time cost by about $550 per worker, per year. See http://www.bigmove.ca/saving-you-time-money.

25 I calculate this as the percentage increase in each person's access to employment within a 2.3 kilometre band of expanded commute length foreseen under the proposed Metrolinx investment strategy. Metrolinx estimates a pre-investment average commuting boundary of 15.2 kilometres.

Table 2: Yearly Cost to Greater Toronto and Hamilton Area Residents of Lack of Access to Surrounding Labour Force

	Strength of Relationship between Urban Population and Income:		
Annual income cost:	**Low**	**Medium**	**High**
Total ($billion)	0.8	1.2	2.1
Per person 15 and over ($)	151	241	422

Note: All prices in 2005 dollars. Low, medium and high scenarios correspond to a doubling of surrounding labour force resulting in income increases of 1.7 percent, 2.8 percent, and 5.0 percent.

Source: Author's calculations from Statistics Canada.

- the assumed rate of increase in income that results from an increase in access to surrounding population, as calculated in Table A-1 and A-2 (see DFT 2005, page 22 for more details).[26]

I then sum the total individual gains across all tracts throughout the Greater Toronto and Hamilton Area, creating a low, middle and high range estimate of the cost of unrealized urban benefits (Table 2).[27] In the mid-range of estimates, I find that the economic cost of unrealized agglomeration benefits are $1.2 billion per year in the Greater Toronto and Hamilton Area. Per person over the age of 15, the total amount is $241 per year. At the low range, the economic cost of unrealized agglomeration economies are $0.8 billion per year, whereas the highest economic cost is $2.1 billion.[28] Similarly, the extent of agglomeration economies also depends on the assumption of the size of the urban area affected. Using the mid-range estimates of the strength of the relationship between location and incomes, I find that increasing the band of newly accessible areas to three kilometres increases incomes by $1.8 billion, and that increasing the size of the accessible region by only one kilometre would increase agglomeration economies by $0.6 billion.

26 The primary difference between my approach and that of DFT (2005) is that I use an aggregate, economy-wide estimate of agglomeration benefits and assume that, on average, workers in a Census Tract benefit by that margin through higher incomes. This is equivalent to assuming that the benefits to firms are capitalized in higher wages or profits retained locally. DFT (2005) produced industry-specific agglomeration benefits that vary widely and calculated the benefits to individuals by the sector they worked in. Such firm-level or industry-specific data is not readily available in Canada.

27 I produce a range of estimates, given that there is a range of plausible estimates of the agglomeration benefit (Graham and Van Dender 2011). The low, medium and high elasticities of income with respect to labour markets that I use here are 0.025, 0.04 and 0.07, which is equivalent to a doubling of population and income increases of 1.7 percent, 2.8 percent, and 5.0 percent. These ranges are similar to those used by Venables (2007). I also assume that there are no agglomeration diseconomies.

28 These annual benefits can be calculated as present values, which depend crucially on assumptions about the compounding of benefits and the appropriate discount rates to use, which is beyond the scope of this analysis.

Benefit 2: Increased Labour Market Participation

Reduced traffic congestion can induce more people to work than otherwise would be the case and, thus, increase the potential real wages – wages minus the monetary and time cost of travelling to a job. These people are on the margin choosing to work or not and reduced congestion and travel time can tip the balance. I calculate the annual economic cost of reduced labour supply due to congestion as $257 million.[29] Per worker, per year, this amounts to $55.[30]

Benefit 3: Induced Commuting or Migration to the City

The last potential benefit of reduced congestion I measure is the increase in wages experienced by people who commute from outside the urban area to inside it. These are people near the margin of preferring to live and work in an area where travel times are insignificant versus traveling a longer distance. Although their net welfare changes relatively little by commuting, they experience an increase in income. An example in Box 2, based on DFT (2005), illustrates this. Although an increase in the ability of people to access new, higher paying jobs will result in an increase in GDP, the longer commutes mean that people incur a higher time cost and inconvenience upon commuting longer. The net change in social welfare is small, despite increases in income.

After controlling for various individual factors that may determine whether people are more likely to seek a higher income job and commute,[31] I find that, nationwide, workers who commute between five and 10 kilometres earn a 6 percent employment-income premium over workers who commute less than five kilometres. Workers who commute between 25 and 30 kilometres earn a 9 percent income premium over those who work within five kilometres from home. The commuting premium is larger for workers in the Greater Toronto and Hamilton Area, with commuters who commute over 30 kilometres earning an approximately 20 percent wage premium over people who do not commute more than five kilometres.

The potential range of increases in income as a result of reducing commuting times may vary based on self-selection of people who have an otherwise higher propensity to commute to a higher paying job, owing to higher intrinsic skill. Although I can control for some observable differences across people, following the same approach as Fu and Ross (2010), there is the potential that wage gains

29 I calculate this using the Greater Toronto and Hamilton Area Census Tract average employment income of $43,000, and I assume that reducing the cost of excess congestion as planned by Metrolinx ($550) increases real wages by 1.3 percent. Based on standard estimates of the degree that people enter the workforce through higher wages – following DFT(2005) – I use an estimate of 0.1. This is at the low range of estimates found by McClelland and Mok (2012) in which a 1 percent increase in wages results in a 10 percent increase in labour supply, as the elasticity of labour supply in response to an increase in wages – multiplied by the number of people in the labour force age (15 and over) and the average employment income these workers would earn. I calculate this benefit as ($550/average employment income in that Census Tract) × 0.1 × Census Tract labour force size × average employment income in that tract.

30 Both Metrolinx (2008a) and DFT (2005) argue that the effect of lower congestion on workers at their existing jobs – such as working longer hours or being less tired because of less time in traffic – is negligible. I do not estimate that potential effect.

31 Specifically, I control for the education level, age group, the province the person lives, sex, occupation, industry and immigration status of workers, whether the worker moved in the previous one or five years, and whether the worker commutes across Census boundaries. I conduct this regression with the Individual Public Use Microdata File. See Appendix for details.

as a result of a policy that increases commuting will be relatively small. Further, people may choose to relocate to an area rather than commute.[32] To address the problem of differing likelihoods of commuting, I have added controls for whether people moved and other individual factors that may influence commuting and income patterns.

I estimate a potential range of economic benefits from reducing congestion for each Census Tract in the Greater Toronto and Hamilton Area as the product of: (i) the average wage premium that people receive if they commute an additional kilometer; (ii) an estimate of how much commute length will increase on average in the Greater Toronto and Hamilton Area as a result of investment plans; (iii) the current employment income of people in each Census Tract; and (iv) the number of people over the age of 15 in the labour force in each Census Tract.

Given the range of potential increases in commuting as a result of reduced travel time and the range of potential effects on wages that could result from increased commuting distance, I produce a range of economic costs of unrealized commuting opportunities for Greater Toronto and Hamilton Area workers (Table 3).[33] At the low end of assumptions on commuting patterns (one extra kilometre driven times wage premium of 0.4 percent), I find that this annual benefit to new commuters is $0.6 billion, with a higher economic benefit of $1.0 billion if workers earn a higher wage (0.7 percent per kilometre) premium upon commuting. A larger increase in the average commuting distance of 2.5 kilometres, along with a high end estimate of workers earning an additional 0.7 percent per additional kilometre they commute results in upwards of $2.5 billion per year. Per worker, this ranges from an economic benefit of $116 per year to $511 per year.

Government Revenues

Lastly, government revenues increase in response to rising incomes or an individual's decision to take a higher-paying job. I calculate an estimate of induced government revenue using a similar approach to DFT (2005), a model that assumes governments collect more income taxes due to increased incomes. I do not add the change in government revenue to the total estimate of income lost due to congestion, as doing so would be double counting. My estimate reflects the portion of induced income growth that would become government revenue. Applying the average marginal effective tax rate of 31.6 percent (Laurin and Poschmann 2011) to the increase in income, I estimate the higher incomes result in higher tax revenues of between $0.5 billion per year at the low range of economic benefits, to $1.5 billion per year.[34]

32 Axisa (2011) finds that people in the GTA who move between 30 and 100 kilometers have the longest commutes, suggesting that people who move these distances do so for personal reasons – such as family obligations – rather than to be close to work. In contrast, people who migrate over 100km have among the shortest commutes, suggesting these people make simultaneous work and residence locations. Commutes over 100km are rare, suggesting that these people would not have commuted from their original location.

33 I do not include the effect of people moving to the Greater Toronto and Hamilton Area from outside the Greater Toronto and Hamilton Area. Any calculation that does would need to reflect both the gains in agglomeration in one area and the losses in agglomeration in the other.

34 These are upper bound estimates, as I do not take into account the marginal cost of funds: the economic harm caused to raise a dollar of revenue.

Table 3: Increase in Income ($billion) Due to Increased Commuting Opportunities, Greater Toronto and Hamilton Area

Increase in Commuting Distance:	Wage Premium of Commuting to Jobs	
	Low (0.4 percent per km)	*High (0.7percent per km)*
Low (1 km)	0.6	1.0
High (2.5 km)	1.4	2.5

Note: These calculations are based on all people in labour force over the age of 15 in the Toronto, Oshawa and Hamilton CMAs.

Source: Author's calculations from Statistics Canada.

To the extent that the federal government collects most income taxes – and a large amount of the consumption tax revenues that will result from higher incomes – it will benefit from infrastructure projects to a greater degree than provincial or municipal governments. Otherwise, there is relatively little argument for federal assistance for local transportation infrastructure projects (Kitchen and Lindsey 2013).

As living in cities becomes more valued by people who now commute to the urban area, property prices there rise. Gibbons and Machin (2005) find evidence of transportation infrastructure increasing local prices by examining an expansion of light rail and subways that linked a previously unconnected area of London, UK to central London. That study found that property values of houses near new transit rose relative to those in the rest of the city. Houses within two kilometres of a station increased in value by between 3 and 12 percent more than houses elsewhere in London over the study period.[35] A property tax that captured this increase in local house values could provide a dedicated revenue stream to fund transit expansion and equate the benefits of infrastructure with who pays for it, akin to a user fee which has no broader economic harm. Although wages will increase as a result of greater agglomeration, the subsequent increase in property values makes it unclear how much the increase in net welfare will be.

Although the value consumers place on transportation improvements will be reflected in higher property values, they may not apply to property values in the municipality in which transportation improvements occur. This creates a potential role for provincial governments to finance transportation infrastructure, partly through a provincial component of residential property taxes[36] – to internalize the benefit of higher revenues.

35 However, not all houses in a city rise in value in the same way because of transit. The London study found that beyond two kilometres from a station, the average value of a house fell by as much as 3 percent, relative to the rest of the city, for each kilometre a house was away from the nearest station. This creates a strong case for a property tax that captures increases in property values in the areas affected by the transit expansion, and does not apply elsewhere.

36 The Ontario government collects a residential and business property tax, ostensibly to finance school board expenditures. However, school spending is no longer linked to property tax revenue, making the provincial property tax a general revenue tool. See Found and Tomlinson (2012) for details.

The Total Economic Cost of Congestion

I calculate the total costs of congestion using a similar method to that from DFT (2005) by summing the currently foregone agglomeration benefits for existing urban residents, commuting benefits, and labour market participation benefits.[37] Tax revenue is a function of the income figures calculated above and I do not sum them with the other effects. The oft-discussed cost of congestion in the Greater Toronto and Hamilton Area of $6 billion (Metrolinx 2008a) per year is an underestimation of the full costs. By taking into account all the economic costs of unrealized income discussed above, I estimate the additional economic costs of congestion are between $1.5 and $5 billion per year.

Conclusions and Recommendations

Governments across Canada have not been accounting for the full costs and benefits of infrastructure investments. In the case of transportation investments, the benefits of urban living – access to a broad range of jobs, activities, and knowledge – exist because of the relationships between people living close together. The evidence from around the world – and Canada – makes clear that greater access to nearby economic activity results in people earning a higher income. When congestion stifles these relationships, it threatens the essence of urban living. In the same way that it is now routine to incorporate the negative externalities of the cost of pollution, governments should include all measurable externalities in the cost-benefit analysis of investments.

Such a cost-benefit analysis of individual projects, applied to transportation, will show that the greatest benefits of transportation improvements occur in large urban areas. These externalities are sizeable in the case of the Greater Toronto and Hamilton Area, ranging from $1.5 to $5 billion per year, on top of the existing economic costs of travellers wasting time in traffic. Road pricing for new roads, new lanes or other improvements would be a good first step to curbing excess congestion.

For Canadian governments, the framework of comparing the private and social returns of investments can apply to a wide range of investments, ranging from transportation to education to health and much more. In cases in which there is a substantial private return, the economically efficient option is for pure private provision. With such a framework in hand, Canadian governments can make better choices about their investment needs.

37 I do not calculate the additional effects of increased competition as DFT (2005) finds this effect to be relatively minor. This is justified by evidence in Combes, Duranton, Gobillon, Puga, and Roux (2012) that the selection effects of firm competition do not drive firm productivity.

Appendix

I calculate the linear distances between the geographical centre points of Census Tracts (CTs) within 50 kilometres of each other. I generate 2.4 million pairings of CTs (or, 1.2 million unique pairs of all CTs in Canada within 50 kilometres of each other). For each CT, I calculate the sum of the total number of people in the labour force over the age of 15 in the surrounding 50 kilometres.[38] This approach, rather than looking at the distance of an individual Census Tract to a central business district, is best with polycentric cities or those where the primary municipality is not in the geographic centre of the CMA. Ideally, I would use travel times based on detailed information about ease of transportation – such as highway access or public transit – but this is computationally more difficult than the approach I use. This distance threshold is approximately the boundary of most CMAs from the central Census Subdivision, meaning that distance thresholds beyond this point would not record any additional population as these areas would not have any Census Tracts. Ideally, I would have used Census Dissemination Areas across all areas, but computing distances between all Dissemination Areas is overly computationally intensive.

For the regressions in Table A-1, my dependent variable is the average after-tax family income. As the Census does not report hourly wages, I use annual family after-tax income. I also conduct tests (not reported) of individual employment and after-tax income, and the results were similar. At the CT level, I use the sum of the surrounding labour market within 50 kilometres as my measure of agglomeration. Both the income variable and the labour-force size are in logs, making these elasticity estimates. However, because I use CTs, which Statistics Canada does not use in rural areas, these regressions do not include rural areas. I add controls for the province where each CMA is predominantly located to control for province-specific effects on income, along with controls of the share of the CT's population with a college or university degree and the share of the population without a high-school degree. The model is similar to that of Rice et al. (2006) who use wages and productivity, and find similar results.

I conduct a similar regression for all Ontario Census Subdivisions, which covers the entire Ontario population. Census Subdivisions are approximately the borders of Ontario lower-tier or single-tier municipalities. However, they also include unincorporated areas and First Nations reserves. I calculate the distance between the geographical centres of all Ontario Census Subdivisions, but limit my analysis to the relationship between Census Subdivisions within 50 kilometres of one another. In the first two columns of Table A-2, I test the relationship between income in a Census Subdivision and the labour-force size in that Census Subdivision, and in Census Subdivisions in the surrounding 50 kilometres. In the last two columns, I examine the relationship of each Census Subdivision's population and income in that Census Subdivision. Again, these are elasticities as the dependent variables and agglomeration variable are in logs. Most of these estimates are close to, or within, the range of those found in international studies of 0.05 for France (Combes et al. 2010), 0.04 for the United States (Glaeser and Resseger 2010) and 0.048 for Spain (de la Roca and Puga 2012).

38 Although not reported here in order to save space (although available from the author upon request), the results are largely the same whether I use 35, 40, 45, or 55 kilometre thresholds. There is some degree of attenuation of the agglomeration variable beyond 60 kilometres in some of the specifications, which is consistent with the findings of Rice et al. (2006). However, the nature of CTs only existing within CMAs, and not in rural areas, means that it is unlikely I am capturing much additional population by expanding the boundaries beyond 50 kilometres.

Table A-1: Effect on Average Family Incomes of Increasing Labour Force Size, Census Metropolitan Area and Census Tract Level

Independent Variable: Average Family Income	Surrounding 50km Around Census Tract		Overall Census Metropolitan Area Size	
Total Labour Force Over 15	0.046*** [0.004]	0.019*** [0.003]	0.067*** [0.016]	0.051*** [0.014]
Controls – Effect on Income				
Relative to Atlantic Canada				
Quebec		-0.067*** [0.016]		-0.071 [0.043]
Ontario		0.118*** [0.015]		0.097*** [0.023]
Manitoba/Saskatchewan		0.041** [0.018]		0.048 [0.039]
Alberta		0.220*** [0.018]		0.175*** [0.057]
British Columbia		0.004 [0.017]		0.026 [0.045]
Share of Population 25-64:	In Census Tract		In Census Metropolitan Area	
With College or University Degree		0.481*** [0.060]		0.108 [0.464]
Without High School Degree		-2.173*** [0.093]		-0.549 [0.718]
Constant	10.680*** [0.047]	10.970*** [0.048]	10.500*** [0.186]	10.660*** [0.237]
Observations	4,982	4,982	48	48
R-squared	0.027	0.498	0.369	0.784

Note: *** p<0.01, ** p<0.05. Standard errors in brackets.

Source: Author's calculations from Statistics Canada.

The Relationship between Commuting Time and Incomes: In the final set of regressions, I assess the relationship between commuting length and income. I use the individual Public Use Micro File (PUMF) from the 2006 Census, which provides information on a very large sample of Canadians. I regress two measures of individual income: employment income, and after-tax income, with largely similar results on a number of factors that influence earnings, including: CMA of residence (the closest available proxy to agglomeration benefits available in the PUMF), province, age group, highest education degree, industry, occupation, sex, whether the person moved in last one or five years (and if so, whether from another Census Subdivision, Census Division, province

Table A-2: Effect on Average Family Incomes of Increasing Labour Force Size, Census Subdivision Level

Independent Variable: Average Family Income	Surrounding 50km Around Census Subdivision		Within Census Subdivision	
Total Labour Force Over 15	0.086*** [0.005]	0.037*** [0.005]	0.108*** [0.005]	0.061*** [0.006]
Controls – Effect on Income				
Share of Population 25-64:	Within Census Subdivision			
With College or University Degree		0.116** [0.049]		0.057 [0.046]
Without High School Degree		-0.271*** [0.033]		-0.271*** [0.031]
Constant	10.230*** [0.055]	10.420*** [0.114]	10.320*** [0.044]	10.290*** [0.104]
Observations	453	449	453	449
R-squared	0.397	0.570	0.464	0.621

Note: *** p<0.01, ** p<0.05. Standard errors in brackets.

Source: Author's calculations from Statistics Canada.

or elsewhere), and whether a person commutes to another Census Subdivision or Census Division for work.

The variable of interest is to assess how much an individual's income increases, after controlling for all other controllable factors, if he commutes a certain distance. The results show that, looking at all people recorded in the Census PUMF across Canada with employment income, people who commute longer distances have higher incomes than those who commute short distances. For example (from column 1 of Table A-3), people who commute five to 10 kilometres have 6.1 percent higher employment incomes than people with commutes of less than five kilometres. People with commutes between 25 and 30 kilometres have 8.6 percent higher incomes than people with commutes of less than five kilometres. I find similar results when looking at individual after-tax income (see column 2 – family income is not available from the Individual PUMF).

Isolating the analysis to people within the Greater Toronto and Hamilton Area (GTHA) and focusing on employment income (column 3), I find slightly larger effects on income of commuting. People with commutes between 10 and 15 kilometres have 7.7 percent higher incomes than those who commute less than five kilometres. Those commuting more than 30 kilometres see an 18.3 percent increase in income relative to those who commute less than five kilometres.

I compute a weighted average income effect from a five kilometres increase in commutes for Canada as a whole and for the GTHA, based on the number of people within each commuting group. Approximately 40 percent fewer people commute 15 to 20 kilometres in Canada relative to those who commute 10 to 15 kilometres. From these groups,

Table A-3: Effect on Incomes of Increase in Commuting Length

	All of Canada		Greater Toronto and Hamilton Area only
Independent Variable:	*Employment income*	*Individual after tax income*	*Employment income*
	percentage increase in incomes		
Relative to people with less than 5km commute			
Commutes 5-10km	0.061*** [0.007]	0.060*** [0.007]	0.086*** [0.016]
Commutes 10-15km	0.058*** [0.009]	0.054*** [0.008]	0.077*** [0.019]
Commutes 15-20km	0.067*** [0.011]	0.068*** [0.010]	0.078*** [0.023]
Commutes 20-25km	0.076*** [0.013]	0.075*** [0.012]	0.139*** [0.027]
Commutes 25-30km	0.086*** [0.016]	0.085*** [0.014]	0.172*** [0.032]
Commutes 30km or more	0.023* [0.012]	0.005 [0.011]	0.183*** [0.025]
Other controls	CMA, province, age group, highest degree, industry, occupation, sex, moved in last five years, moved in last year, Census Subdivision of work, whether commuting not applicable		
Observations	486,988	657,421	101,666
R-squared	0.385	0.261	0.380

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in brackets.

Source: Author's calculations from Statistics Canada.

I estimate that the average effect within Canada of increasing commutes per additional commuting kilometre is a 0.4 percent increase in incomes. In the GTHA, increasing commutes by one kilometre increases incomes by 0.7 percent. These estimates provide an upper and lower bound estimate of the income benefit we can expect if people increase their commute length as a result of reduced congestion.

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