Economic Benefits of Major Transportation Investments

An Overview

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1. Introduction

The purpose of this briefing is to provide an overview of the full range of benefits (and costs), including potential economic impacts, which may arise from a Metrolinx Investment Strategy consisting of a package of major transit and related capital projects, drawn from The Big Move, as well as associated operating and maintenance funding.

The evaluation of major transportation infrastructure projects over the years has been undertaken using a variety of approaches. In the North American setting, many studies have examined such capital projects through their impact on employment and output, particularly during the construction phase. There has recently been considerable renewed interest in these "economic impact" studies in the wake of the recent recession. At the same time, regional transit agencies have continued to conduct benefit-cost assessments of major capital projects, which identify the travel time and cost savings among other impacts likely to arise from the new or enhanced services made possible by the infrastructure investments. The latter studies are based on the changes in travel behaviour enabled by the major capital investments and their implications for travel time, costs and environmental impacts. In more recent years, there has also been a growing literature and policy interest in examining how transportation projects affect the performance and competitiveness of the wider economy, with a particular focus on productivity and the effective operation of labour market.

This briefing will provide an overview of all these economic impacts and benefits, describing the purpose and limitations of each. It will also review the potential wider economic benefits of transportation infrastructure projects as well as any other economic impacts (or factors which drive economic impacts) which are not included in the above categories. In this respect, it will attempt to weave a picture covering different types of impacts and explaining which ones can be considered additional or incremental (i.e. impacts which are lost if we don't proceed with the investment), which ones cannot, and which impacts potentially overlap with other impacts (i.e. double-counting). As a result, this briefing will serve as guidance for thinking about the different economic impacts discussed in connection with major transportation projects under the Metrolinx Investment Strategy and how these impacts align with the Multiple Account Evaluation framework for benefit case assessments currently used by Metrolinx and other major transit agencies.

Section 2 reviews the standard economic impacts of transportation projects, including the results of input-output models and macroeconomic models. Section 3 reviews the microeconomic impacts captured under conventional cost-benefit assessments of transportation projects. Section 4 examines the wider economic impacts of transportation programs and discusses which of these are incremental and hence additive to conventional cost-benefit results. The last section identifies several other socio-economic and environmental impacts sometimes mentioned in the context of transportation project appraisals.

2. Standard Economic Impacts of Transportation Capital Programs and Related Activities

In this section we provide a brief overview of the standard economic impacts resulting from capital investment programs such as the one envisaged under the Investment Strategy. These economic impacts illustrate how a defined set of expenditures – representing the capital, labour and materials costs required to undertake an investment – can generate demand for labour and demand for goods and services during the design and construction phase as well as during the operations and maintenance phase. The impacts are usually reported for variables such as employment, output (i.e. GDP), consumption, trade (exports and imports), investment and government revenues. In some cases, impacts are also reported on an industry by industry basis. Standard economic impacts consist of up to three components:

- **Direct impacts** refer to the employment, output and other impacts generated by the first round of spending required to undertake the investment program. For example, direct employment impacts consist not only of the workers employed on the construction site, but also the labour component of the first round of materials expenditures which are sourced from the area under study
- **Indirect impacts** measure the jobs, output and other impacts created as a result of further rounds of spending undertaken by suppliers in order to support the first round of expenditures
- **Induced impacts** measure the jobs, output and other impacts created as a result of the re-spending of all the incomes earned under the first and additional rounds of expenditures (i.e., wages and profits earned by all the direct and indirect suppliers)

Economic impact studies always report the direct impacts of a project and often report both the direct and indirect impacts. Induced impacts are not always included in the reporting, for reasons we explain below when looking at the two types of economic impact models.

These standard economic impacts are always captured for a defined geographic area – usually either Canada as a whole or one province in particular. In some cases, the models also provide local or regional impacts, such as in the case of the C4SE Ontario Regional Economic Model, which shows impacts for the GTA and other regions of Ontario. One feature of many of these models is that they often show how the impact of the spending tends to “spill over” from the study area to other areas, and benefit regions beyond the study area. This effect depends on how the type of goods and services required for the investment program match the productive capacity of the study area.

Standard economic impacts can be derived from two very different types of models – either input-output models or macroeconomic models. While both models have emerged from the economics profession and provide a view of demand-side impacts of a project or initiative, the first type of model is a detailed accounting model which captures all interindustry relationships in the economy, while the second type (macroeconomic models) captures the aggregate economic relationships between such variables as consumption, employment, investment, trade, relative prices, and inflation, with explicit consideration for the limits of the economy’s productive capacity. We discuss each of these in turn.

2.1 Input-Output Models

Input-output models are designed to trace the impact of an initial set of expenditures (say, for a capital project), including spending on construction, track infrastructure, and rail vehicles, into the final demand for goods and services in the economy, by using a detailed snapshot of all the inter-industry relationships in the economy at one point in time. The inter-industry relationships illustrate how each industry relies on inputs from all other industries and also how the value added (or GDP) from each industry is sold to all other industries (i.e. in what proportions). As a result, input-output models can be used to determine how an initial set of spending results in direct impacts on output, employment and other variables. These direct impacts are then transformed into spending on intermediate goods and services in order to yield the indirect impacts on the same variables. Employment impacts (both direct and indirect) are derived from employment/output coefficients which show the average amount of labour required to produce a unit of GDP in each industry. In some cases, the induced impacts are then derived from the income earned by both the direct and indirect suppliers, which is re-spent on goods and services.

In the Canadian context, Statistics Canada has developed a family of input-output models (a national model as well as an inter-provincial model) which covers all the transactions between industries, including the government sector. This input-output data forms an integral part of the Canadian System of National Accounts (CSNA) and is reported on an annual basis.[1] As such, the main advantage of this data is that it provides a detailed representation of the inter-industry structure of the Canadian and provincial economies, which in turn is consistent with the rest of the CSNA (i.e. including the income and expenditure accounts and the balance of payments). Some provinces, such as British Columbia, also have their own input-output tables and model.

Input-output tables can also be used to derive multipliers, which in this context we define as the ratio of the total impacts to the initial level of spending for output and other impact variables. The multipliers from so-called "closed" input-output models capture the direct, indirect and induced impacts and as a result, yield relatively high multiplier values (e.g. GDP multipliers well over unity). However, these types of multipliers have fallen out of favour in the last decade, because they yield exaggerated estimates of project impacts.[2] Most responsible practitioners of input-output analysis rely on multipliers from "open" IO models, which exclude induced effects and thereby yield significantly lower multipliers (e.g. GDP multipliers less than unity).[3]

Figure 1 below is one recent example of economic impact results derived from Statistics Canada's input-output multipliers. It reports the direct and indirect economic impacts resulting from $2.47 billion of capital investments in public transit across Canada in 2007. This investment led to an increase in output of $3.7 billion, implying a multiplier of 1.49 (excluding induced effects). The direct and indirect employment impacts from the capital investment amounted to 22,600 full-time equivalent jobs. Similarly, the tax revenue impacts of the capital investment included only the direct and indirect effects. The table also reports the direct employment impact from all transit operations in the same year, driven by $5.49 billion of transit operating expenditures.

[1] See Statistics Canada *The Input-Output Structure of the Canadian Economy, 2006/2007*, the latest available publication in this annual series from http://www.statcan.gc.ca/pub/15-201-x/15-201-x2010001-eng.pdf.

[2] This is in part because the induced spending does not take into account macroeconomic feedback effects that cause the multiplier effects dissipate over time (e.g. higher spending can be inflationary if the economy is operating at high levels of capacity utilization. See Patrick Grady and R. Andrew Muller "On the Use and Misuse of Input-Output Based Impact Analysis in Evaluation" *Canadian Journal of Program Evaluation*, 1988. Downloaded from http://global-economics.ca/input.output.multipliers.pdf.

[3] For example, Statistics Canada no longer supports closed IO model runs. Their multipliers include only direct and indirect effects. See http://www.statcan.gc.ca/nea-cen/faq-foq/io-es-eng.htm.

Figure 1: Economic Impacts of Public Transit in Canada, 2007

METRIC	ANNUAL IMPACT
Economic output (increase in GDP)	$3.7 billion
Employment from capital investment	22,600 full-time jobs
Taxes arising from capital investment	$160 million
Employment from transit operations	45,300 full-time jobs

Source: Canadian Urban Transit Association, "Measuring Success: The Economic Impact of Transit Investment in Canada" Issue Paper 35, May 2010 and the background report entitled *The Economic Impact of Transit Investment: A National Survey*, p. 36.

There are important limitations to the use of input-output models and associated multipliers. These limitations can be summarized in the caveat that the economic impact results from input-output models should not be considered incremental in the strict sense of the term (i.e. the output and employment impacts cannot be considered lost if the investment or project under study were not implemented).[4] This is partly because input-output models do not include any concept of the limits to the productive capacity of the economy. There is no feedback mechanism whereby the investment spending affects wages and inflation (or the relative prices of goods and services), as there is in macroeconomic models. Secondly, the impact results cannot be considered incremental because input-output models are not designed to net out the opportunity costs of the resources used for the investment under study. In other words, if the workers, materials and consumables are used to develop a new transportation facility, these resources would not be available for any alternative uses. Interpreting the employment and output results of input-output models as incremental would amount to assuming that the workers and materials used to build the facility would otherwise remain unemployed or unused without the project – an unrealistic assumption in most circumstances. Third, the input-output results are based on the average structure of the economy, due to the linearity of the model, and do not represent the effects at the margin (e.g. the results assume that any additional labour hired requires the same proportion of overhead labour as may already be incorporated in the historical industry structure). As a result, when input-output based impact studies report that a project creates "x" number of jobs and "y" GDP, this should be understood as a description indicative of the potential magnitude of the project rather than a prediction of the net new jobs and output which will be added to the economy.

[4] These economic impacts are not incremental in part because they can be partially or even fully offset by changes in employment and output elsewhere in the regional economy. These offsetting effects are sometimes known as "crowding out" effects.

2.2 Macroeconometric Models

In contrast to pure input-output models, standard macroeconomic models are designed to capture the aggregate economic relationships for a given economy. Macro-econometric models of the economy typically focus on forecasting the main aggregates, such as output, employment, investment, wages and the general price level. They also illustrate how these variables adjust dynamically over time, as an economy adjusts to a particular external shock (e.g. a decline in export demand from a major trading partner) and output and employment gradually revert to their equilibrium or steady-state growth rates.[5]

The objective here is not to describe the detailed workings of macroeconometric models, but to discuss how the economic impact results from these models differ from those based on input-output models.[6] There are several distinguishing features of the results which emerge from simulating the impacts of capital investments using macroeconometric models:

- the reported multipliers capture the combined direct, indirect and induced effects
- the results take into account the feedback effects of the investment spending on wages and prices, thereby recognizing the limits imposed by the productive capacity of the economy and the risks of mitigating the impacts on real output and employment gains
- macroeconometric models also usually show the impact of major investment programs on the labour force, including the labour force participation rate and inter-provincial migration
- the macroeconometric results are not based on the average structure of the economy as in input-output models, but reflect the impacts at the margin

One example of a macroeconometric model simulation showing the economic impact results of a major investment program can be drawn from a recent Conference Board of Canada report. The report illustrates the impact of spending $18.5 billion of spending on rapid transit projects in current dollars over the 2009-20 period, using the Conference Board's macroeconometric model of the Ontario economy.[7]

According to the report, the investment spending would lead to an increase in GDP of $22.7 billion for the Province of Ontario over the total period, including direct, indirect and induced impacts. The implied multiplier (the ratio between the total GDP impact and the initial spending) is 1.19. This increased level of economic activity does have a knock-on effect on wages and prices in the Ontario economy, but these effects are very modest (0.06 per cent and 0.21 per cent respectively over the period). In terms of the labour market, the employment impact is calculated at an additional 229,000 person-years of employment, including indirect and induced impacts. This increased demand for labour also draws 172,000 additional workers (person-years) into the Ontario labour force partly as a result of inter-provincial migration and partly due to a higher rate of labour force participation among the working age population.[8]

A more recent macroeconometric simulation was conducted by the Centre for Spatial Economics

[5] The steady state growth rate is determined by the growth rate of the labour force (including the quality as well as the quantity of labour) and population as well as the long-term productivity growth rate.
[6] See Centre for Spatial Economics " The Economic Impacts of Metrolinx Transportation Project Scenarios" Aug 2012 for an example of the workings of a macroeconometric model based on standard neoclassical theory.
[7] See V. Gill, M. Iacobacci and P. Owusu, *Connecting Jobs and People: Exploring the Wider Benefits of Urban Transportation Investments*, Conference Board of Canada, August 2011.
[8] See Gill et. al. *Connecting Jobs and People:* p. 7 (Table 1) for the GDP results. Other data discussed in the paragraph above, including the multiplier, job creation and labour force numbers, are reported in Table 1 in Appendix A of the report.

(C4SE) as one element of an overall economic analysis of the Metrolinx Investment Strategy. The macroeconometric simulation was undertaken for several capital spending scenarios, including a scenario consisting of $58.4 billion in capital spending over the period between 2012 and 2031 (expressed in $2014 currency). The analysis also took into account additional operating and maintenance spending which would result from providing the additional public transit services made possible by the capital investments ($87.7 billion in 2014 currency). The results suggested a real GDP multiplier of 1.5, which means that every dollar of capital and operating spending associated with the Investment Strategy would be expected to generate $1.5 in real GDP terms over the period between 2012 and 2031. In dollar terms, the scenario would generate an additional $225.6 billion in real GDP (in $2014 currency) for Ontario over the 2012-31 period as a whole.[9]

It is worth noting that the 1.5 GDP multiplier is considerably larger than the 1.19 multiplier obtained from the Conference Board model. One reason which likely accounts for much of the difference is that the Ontario population is exogenous in the Conference Board model, while it is endogenous to the C4SE model (i.e. in the latter model, there is additional net in-migration to Ontario as a direct result of the increased economic activity spurred by the major capital program).[10]

There are two caveats to note in interpreting the C4SE multiplier. First, the multiplier captures the cumulative impact of the investment and associated operations spending through to 2031, but it is not a long-run multiplier, because it does not capture the results beyond 2031, even though the new transit assets will continue to be in service. Second, the multiplier captures spending on a mix of capital projects, which start and end at different times. Hence, it is not a project-specific multiplier and should not be considered a representative impact of any one transit project over its useful economic life. The latter caveat also applies to the Conference Board results.

Macroeconometric models also have important limitations in the context of analyzing the overall economic benefits of capital investment programs. As in the case of input-output models, the economic impacts from macro-econometric models cannot be viewed as incremental in the strict sense of the term (i.e. the output and employment impacts would not necessarily be entirely foregone if the investment program were not implemented). This is because macroeconomic models are not designed to net out the full opportunity costs of the labour, capital and material resources used up in the investment program. Nor do they include microeconomic benefits that emerge from the capital investment over the life of the new investment – notably, the time savings and any cost savings that accrue to current and potential commuters and other travelers. This is not at all surprising, because macroeconometric models were designed to forecast economic aggregates, rather than to capture the full welfare costs and benefits of particular investment strategies.[11]

The macroeconometric models discussed above are some of the best tools available to forecast the course of the provincial and national economies. As such, they have an important role to play in illustrating the economic impacts of a major capital investment program, particularly in terms of

[9] The 1.5 multiplier is the result of the ratio of of the GDP impacts ($225.6 billion) to the sum of the capital spending and the operations and maintenance spending ($58.5 billion and $87.7 billion respectively). See Centre for Spatial Economics' report on " The Economic Impacts of Metrolinx Transportation Project Scenarios" for the complete GDP results for Ontario and the main regions thereof.

[10] Predicting the impact of capital spending on population growth may not be material for individual capital projects, but it is a valuable feature for understanding regional economic impacts when estimating the impact of a multi-project and multi-billion dollar capital program such as the one enabled by the Investment Strategy.

[11] In fact, macroeconomic models are not designed to capture any welfare costs and benefits which are not already included in the national accounts (e.g. any changes in consumer surplus).

how these impacts may interact with other short and medium-term shocks to the economy. However, the economic impact results are not directly comparable to or additive with those of a benefit-cost analysis.

There is room for enhancing the use of macroeconometric simulations of capital investment programs. One such innovation is to identify all the time and cost savings resulting from the capital investments which may reasonably be captured as productivity improvements in the national accounts (i.e. excluding any improvements in welfare, which would not be reflected in a reduction in out-of-pocket costs or in higher wages). These cost savings (or higher net wages) can be simulated through the macroeconometric model in order to illustrate their impact on consumption as well as the impact on output, employment and investment. For example, the C4SE macroeconomic simulation described above included several cost reductions. Based on a transit network and service improvement scenario that leads to112.6 million fewer vehicle hours travelled in 2031, the following cost reductions for the purpose of the macroeconomic simulation for 2031 were incorporated into the model (all figures expressed in 2014 $):[12]

- a reduction of $433 million in labour costs for businesses, based on the assumption that business trips would have accounted for about 10% of the reduction in vehicle hours travelled and that average hourly labour costs are $35.8. This cost reduction represents a productivity improvement for businesses in Ontario
- reduced auto operating costs of $649 million for consumers and businesses, based on a reduction of 1.18 million vehicle kilometres travelled. The cost reductions for businesses represent productivity improvements, while consumers are able to redirect the auto operating savings to other goods and services (or to savings)
- reduced safety costs of $91 million for consumers and businesses due to fewer accidents associated with fewer vehicle kilometres travelled. Again, the cost reductions for businesses represent productivity improvements, while consumers are able to redirect their spending to other goods and services

By incorporating these cost reductions (i.e. productivity improvements) into the macroeconometric simulation, the results provide a better picture of the economic impacts of the rapid transit investements, including the changes in consumer expenditures which result from the reduction in auto operating costs.

2.3 Models Based on Aggregate Production and Cost Functions

Aggregate production and cost function models have also been used to calculate the productivity effects of investments in public infrastructure, but these models have usually examined the effects of public infrastructure as a whole, including energy, water and wastewater infrastructure rather than transportation infrastructure in particular.[13] For example, a recent report which examined the impact of Ontario's investment in public infrastructure found that the public sector capital stock contributed an average of 0.2 per cent per year to labour productivity over the past thirty years. But it also found that public infrastructure had a larger impact in the 2000s than in earlier decades, specifically accounting for 24 per cent of Ontario's labour productivity growth in the 2000s as compared to only 8 per cent of Ontario's labour productivity growth in the 1990s.[14]

[12] An equivalent set of cost reductions were estimated for 2021, using GGH model runs. Impacts for the years before 2021 and between 2021 and 2031 were extrapolated linearly based on the average annual growth rate in the impacts between 2021 and 2031.

[13] One exception is David Gillen "Public Capital, Productivity and the Linkages to the Economy: Transportation Infrastructure" School of Business & Economics, Wilfrid Laurier University, 2000.

[14] See Pedro Antunes et. al. *The Economic Impact of Public Infrastructure in Ontario*, pp. 15-16, The Conference Board of Canada, 2010.

3. Microeconomic Impacts Captured Under Cost-Benefit Assessments

This section reviews the typical benefits and costs of major transportation infrastructure projects as covered under conventional cost-benefit analyses. Cost-benefit analysis is the generally accepted analytical tool of choice in transportation economics for the evaluation and justification of major transportation network improvements, including capital projects as well as changes in user fees, fare structures and the pricing of travel in general.

In contrast to economic impact analyses covered in the last section, these costs and benefits are derived based on the capital and operating costs of the project and the microeconomic decisions of individuals, households and businesses – before and after the project under evaluation is put in place. The scope of impacts covers all resulting changes in private and social welfare. This means that the evaluated benefits and costs cover changes in:

- consumer surplus – the difference between the value individuals attribute to a trip and the out-of-pocket costs and time costs incurred on the trip
- externalities of travel behaviour – defined as those costs and benefits which each individual trip imposes on other travellers or on the public at large and which are not absorbed in individual travel decisions. These externalities include costs of environmental emissions (although some of these emission costs may already be factored into individual travel decisions as a result of fuel taxes) and some but not all congestion costs[15]

These costs and benefits are designed to be quantified and valued on an incremental basis. This is an essential feature of cost-benefit theory, which in turn allows this methodology to be used as the primary tool for project justification. In other words, the evaluated costs and benefits are inextricably linked with the project or investment program under evaluation – they are only realized if the project is implemented.

Itemized benefits and costs typically evaluated by transit agencies in Canada for each option under consideration (relative to a base case) include:

- travel time savings, including lower generalized costs from fewer or more convenient interchanges, based on value of time estimates related to journey purpose (business travel, commuting to/from work, and other trip purposes)
- financial (out-of-pocket) costs incurred or saved, including capital costs, operating and maintenance costs, savings in automobile usage costs and other out-of-pocket costs, such as parking charges, fares or road tolls over the evaluated horizon
- safety impacts, which attributes financial (i.e. out-of-pocket) and welfare costs to accidents, including those which result in minor injuries, serious injuries and death
- environmental costs, including changes in the economy-wide costs and welfare costs associated with greenhouse gas emissions as well as changes in local air emissions

These benefits and costs above are usually based on trip and travel time changes by mode obtained from simulations of transportation network models for each option under evaluation (relative to a base case). These models are typically four-stage transportation models with

[15] The presence of negative externalities, such as environmental and congestion costs, suggests that the demand for travel may well exceed the optimal level. The greater the externalities, the more the level of travel demand is likely to diverge from the optimal level.

detailed representations of the surface transportation network and its capacity. The models rely on population and employment forecasts, which are exogenous to the model and which in turn drive trip generation rates. The models also rely on land-use input assumptions. All of the above population, employment and land-use assumptions are usually held fixed between alternative scenario evaluations.[16]

Figure 2 below shows all the impacts that are typically evaluated in Metrolinx benefit case assessments; whether or not these are quantified and monetized; and whether or not each of these can be considered incremental in the sense discussed earlier.

Figure 2: Impacts Typically Evaluated in Metrolinx Benefit Case Assessments

ACCOUNTS[3]	IMPACTS	MONETIZED	INCREMENTAL
Transportation User Benefits Account	• Travel time savings • Automobile operating cost savings • Safety benefits	Yes Yes Yes	Yes Yes Yes
Financial Account	• Ridership revenues • Capital and operating costs	Yes Yes	(1) Yes
Environmental Account	• Greenhouse gas emissions • Local air quality impacts, incl. public health impacts • Noise and vibration impacts	Yes No No	Yes Yes Yes
Economic Development Account	• Standard economic impacts (construction and operations phases) • Land value impacts	Yes Yes	No No
Social Community Account	• Land use shaping • Health and accessibility	No No	(2) (2)

Notes:

(1) Ridership revenues are usually not incremental because the value is already captured in the transportation user benefits account. Fare revenues reflect the willingness to pay for transportation improvements,

(2) The incrementality of social and community benefits can be difficult to evaluate and should be done only on a case-by-case basis.

(3) The five accounts in this column correspond to those of the Metrolinx Benefit-Cost Analysis template, which is based on a multiple account evaluation approach.

Source: AECOM analysis based on Metrolinx benefit case assessments completed to date.

In addition to the impacts listed in Figure 2, some benefit-cost analyses of transportation infrastructure improvements also quantify and monetize the following types of project impacts:

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[16] Note that classic transportation network models rely on behavioural elasticities sourced from outside the models, with the risk that the elasticities selected may be arbitrary. An explicit econometric analysis of travel demand choices, based on microdata from the region under study would generate a consistent set of elasticities which could then also be used to simulate the impact of policy variables (e.g. road pricing) that affect travel costs and travel time.

- Service frequency – for example, a transit service every 15 minutes is more valuable than one offered every 30 minutes
- Travel time reliability – the lower the reliability (or the greater the variance), the greater the time buffer that travellers allow to ensure punctuality
- Punctuality of public transit services (esp. rail services) – this is measured as the number of minutes a train service is late (relative to schedule) multiplied by the affected passengers. (Note that this punctuality impact is similar to the travel time reliability impact, but the latter usually applies to auto travel while the former applies to public transit services)[17]
- The quality of passenger journeys – which include measures of the comfort of in-vehicle journeys (e.g. number of passenger minutes spent in crowded conditions in public transit vehicles, multiplied by a disutility or associated welfare cost). In the UK, some benefit-cost studies have also measured the impacts of new rolling stock on passenger comfort levels.
- Surface water quality impacts due to discharges related to vehicle traffic (both auto and public transit vehicles)
- Health impacts of air contaminants, such as sulfur dioxide and nitrogen oxides emitted by autos, trucks and public transit vehicles. These impacts include financial costs imposed on the healthcare system, lost output and productivity from foregone hours of work and premature deaths and the additional welfare costs of living with a relevant illness (e.g. respiratory illnesses)[18]

All of the above impacts are considered incremental, with the first four belonging to the transportation user benefits account; the fifth belonging to the environmental account and the sixth belonging to the social community account.

It is also important to note that benefit case assessments need not be limited to transportation infrastructure projects, but can also be applied to changes in government policies, such as the introduction of revenue tools (e.g. road pricing, new or increased parking charges) which directly affect the cost of travel (and indirectly affect travel time through impacts on congestion) and hence, the demand for travel. Any resulting change in travel behaviour would inform the incremental impacts for the transportation user benefits account and the other accounts.[19] Other types of policy or structural initiatives which have been evaluated using the same approach include changes in regulations affecting the transportation sector (e.g. introduction of lower speed limits) or even the privatization of certain state-owned corporations (e.g. CN).

[17] Note that if door-to-door trip times are used, then travel time reliability can apply to both auto travel and public transit services and thereby capture the full impact of transit service punctuality.
[18] For example, in a recent analysis of a Metrolinx rapid transit projects, an AECOM report found that the local air emissions savings would be valued at $770,000 in 2031 (in 2012 $) for every 100,000 fewer peak hour vehilce kilometres travelled (VKTs). These savings consist of the averted health care costs and increased productivity from fewer lost hours of work as a result of reductions in criteria air contaminant, such as carbon monoxide, nitrogen oxides, volatile organic compounds, sulphur dioxide and particulate matter. See AECOM "Social and Community Benefits of Metrolinx Rapid Transit Projects", prepared for Metrolinx, September 2012.
[19] For example, the UK Eddington Report (2006) examined the cost-benefit impact of a national road pricing scheme, although it did not rely on a multiple account approach to evaluation.

4. Wider micro-economic impacts

Over the last decade, our understanding of the relationship between transportation infrastructure investments and the performance of the wider economy has taken a significant step forward. A seminal report on this topic was published by the UK Department for Transport (DfT) in 1999 called *Transport and the Economy* (also known as the SACTRA report).[20] It examined several topics regarding the wider economic impacts of transportation investments (i.e. beyond travel time and cost impacts) and also sought to identify any additional impacts (positive or negative) which may not already be incorporated in the kind of conventional cost-benefit analysis reviewed in section 3 above. The report examined these wider economic implications of transport investments for the following areas:

- reorganization or rationalization of production, distribution and land use
- effects on labour market catchment areas and hence labour costs
- increases in output resulting from lower costs of production
- stimulation of inward investment
- unlocking inaccessible sites for development
- triggering growth, which in turn stimulates further growth

The SACTRA report highlighted the fact that under conventional cost-benefit analysis, the benefits that accrue to transportation users – time and cost savings to passengers and shippers in the case of goods movement – are always assumed to be equal to the total benefits for the economy as whole.[21] In other words, while the user benefits propagate through the wider economy through reduced wage costs, lower prices and higher property values, the overall effects are no greater than the original sum of travel time and cost savings. However, this result only holds if markets are perfectly competitive. In practice, we know that most markets are not perfectly competitive (i.e. prices do not equal marginal cost) and this is particularly true for labour markets.[22] So long as buyers and sellers (or firms and workers) have some market power and hence, some ability to influence wage and price outcomes, the wider economic impacts of transportation projects may differ from the user benefits calculated for the transportation sector alone. These wider impacts can be either positive or negative, depending on whether prevailing prices are higher or lower than marginal social costs. The difference between prices and marginal social costs captures several factors, including the divergence between prices and marginal output costs, taxes, subsidies and externalities such as environmental, safety and congestion costs.

Based on the results of the SACTRA report and subsequent work undertaken for the DfT, the transportation appraisal guidance for the UK was adjusted to take into account the following wider economic impacts:

- Agglomeration economies, which arise from the increased spatial concentration of economic activity
- Increased competition, which can be measured through reductions in the wedge between prices and marginal costs
- Increased output in imperfectly competitive markets

[20] UK DfT (1999). Transport and the Economy (SACTRA).
[21] This does not preclude the fact that environmental benefits are additional to the transportation user benefits.
[22] See Iacobacci, M. *Interindustry Wage Differentials: Evidence, Explanations and Potential Distortions*. Working Paper 94-04. Ottawa: Department of Finance, 1994.

- Economic welfare benefits arising from increased labour supply

We examine each of these impacts in turn.

4.1 Agglomeration economies

Agglomeration economies arise when increased concentration of economic activity generates productivity benefits through labour market pooling, knowledge spillovers, specialization and the sharing of inputs and outputs. For example, when a firm decides to locate additional production in a certain urban area and thereby increases the concentration of economic activity in that area, it captures only part of the benefits of that decision (through higher profits). The portion of the benefits that accrue to other firms (or to workers) in the same area are known as agglomeration economies (or externalities). If these agglomeration effects were not externalities (i.e. if the benefits were captured fully by each firm making the production location decision), there would be no case for devising transportation policies (or any other policies) for encouraging the spatial concentration of economic activity.

It is important to understand the agglomeration impacts of transportation infrastructure investments for at least two reasons. First, agglomeration economies fully capture the role of transportation infrastructure in achieving an integrated labour market and thereby driving productivity gains and improvements in living standards.

The second reason is that the productivity gains from agglomeration economies are partly incremental to the project benefits calculated in conventional benefit-cost analyses. Hence, these gains can influence project justification as well as project prioritization (if some projects are expected to enjoy proportionately higher agglomeration economies).

There are two types of agglomeration economies: (1) localization economies, which refer to productivity gains that firms derive from their proximity to other firms in the same industry (e.g. industry clusters, such as Silicon Valley); and (2) urbanization economies, which are productivity gains due to city size and are attributable specifically to the scale of product and labour markets.

Localization economies

Localization economies were originally discussed by Alfred Marshall in the late 19th century and are attributed to (i) the benefits of labour market pooling for firms with similar specialized needs, (ii) knowledge sharing and spillovers due to the interaction between such firms, and (iii) the sharing of intermediate inputs between such firms. Localization economies are industry-specific and tend to be most important in financial services, professional services as well as in high-technology sectors. These are all sectors in which firms rely on large and geographically extensive labour markets to find qualified workers.

Urbanization economies

Urbanization economies are attributable to (i) the scale of product markets and labour markets, (ii) access to local public goods (health, education, policing) which are of a higher quality or a lower unit cost, (iii) consumption benefits associated with a critical mass of cultural, entertainment and leisure activities and (iv) any benefits derived from other types of inter-industry interaction.

Both types of agglomeration economies are now incorporated in the DfT appraisal guidance, based on the empirical work of Dan Graham.[23]

[23] D. Graham "Agglomeration, Productivity and Transport Investment" *Journal of Transport Economics and Policy, 41* (September 2007): 317-43.

It is particularly important to estimate agglomeration economies resulting from transportation investments in a region like the GTHA, because the region is characterized by a fragmented labour market (outside the downtown core). [24] Conventional transportation infrastructure investment appraisals focus on the travel time savings and congestion relief resulting from the transportation improvements, but they do not fully capture the economic returns from achieving an integrated labour market, thereby understating the productivity gains and improvements in living standards which can be achieved as a result of transit investments in the GTHA region. The labour market accounts for approximately 60 per cent of people's incomes in the GTHA (profits and returns on investments are other income sources). As such, even a small improvement in the efficiency of the labour market can have a significant impact on the productivity and competitiveness of the GTHA.[25]

4.2 Increased Competition

If output markets were perfectly competitive, there would be no output effects from changes in transportation costs. However, the very existence of significant transportation and logistics costs means that output markets are imperfectly competitive in the sense that output prices will tend to be higher than marginal production costs. This opens up the two potential channels whereby reductions in transportation costs can impact output:

(1) lower transportation costs provide incentives for the affected firms to increase output, provided they face an upward-sloping supply curve – which we examine below in section 4.3

(2) the transportation improvements may also increase product market competition by opening up any hitherto relatively isolated areas to competition from firms outside the area

In principle, this mechanism operates by reducing the mark-up of prices over marginal cost. However, this mechanism is unlikely to have a significant impact in areas such as the GTHA, which are already relatively densely populated and already have highly developed transportation networks. By way of example, the UK appraisal guidance recommends that this second channel is only relevant by exception, notably where a transportation project represents a very significant improvement to accessibility for an area and where there is evidence of a lack of competition in certain markets in that area.

4.3 Increased Output in Imperfectly Competitive Markets

This third wider economic impact refers to the increase in output which arises when firms that benefit from lower transportation and logistics costs respond by lowering their prices, thereby stimulating demand. This increase in output is independent of whether or not there is an increase in competition (i.e. the wider benefit described in section 4.2). It depends only on the presence of imperfectly competitive markets, as reflected in an upward-sloping supply curve.

If businesses benefit from lower freight and logistics costs and/or lower labour costs associated with more effective commuter transportation,[26] they will tend to lower their output prices and

[24] According to the AECOM report "Agglomeration Benefits of Metrolinx Rapid Transit Project Scenarios" prepared for Metrolinx (Draft, June 2012), the agglomeration impacts amount to approximately 11% of the value of the time savings for one of the scenarios analyzed.

[25] The efficiency improvement can be achieved through a better matching between worker characteristics and job vacancy requirement, thereby resulting in lower unemployment and higher job match values. The latter value is shared between higher wages and higher profits.

[26] More effective commuter transportation is measured in terms of unit costs (e.g. cost per passenger-km), but it must take account not only of out-of pocket costs (e.g. fares, auto operating costs) and time

thereby raise output to respond to the increased demand. This benefit is incremental to the time and money savings estimated under conventional cost-benefit analysis and it can be calculated as the product of (1) the difference between the price and marginal cost of output and (2) the increase in output made possible by the lower transportation costs. A rudimentary review of research by the UK Department for Transport has suggested that this wider economic benefit could amount to roughly 10 per cent of the value of the time savings achievable by businesses as a result of transportation improvements.[27] The output effects of lower transportation costs could well be significant for the GTHA and would depend directly on the magnitude of the value of time savings for businesses,

4.4 Economic Welfare Benefits from Changes in Labour Market Behaviour

The fourth set of wider economic benefits arises from changes in labour market behaviour resulting from lower commuting costs, including increases in labour supply and the relocation of existing workers to more productive jobs.

Reductions in commuting costs can affect incentives to work and hence the supply of labour to the catchment area and businesses therein benefiting from the transportation improvement. One supply response can take the form of encouraging some people to join the labour force, since lower transportation costs translate into higher take-home pay. A second supply response can take the form of existing workers working longer hours, which is made possible by any time savings from commuting. These mechanisms which boost labour supply and labour force participation can also affect groups with marginal attachment to the labour force or socially-excluded groups living in areas with poor public transit connectivity.

Lower commute times and/or money costs can also enable some workers to switch to more productive jobs – i.e. from firms with low-productivity jobs to those with high-productivity jobs. It is well-known that workers with longer commute times also tend to have higher wages.[28] To the extent that these wages are indicative of higher labour productivity, then lower commuting costs could enable some workers to switch to higher-paid and more productive jobs.

The switch to more productive jobs can also be understood in terms of improving how workers and job vacancies are matched. The quality or productivity of job/worker match is not fixed, but depends on the size and quality of the labour pool that businesses can choose from and conversely on the size and quality of job vacancies available to job seekers. A wider geographic area over which workers are willing to search for (and accept) jobs translates into a larger and higher quality pool of candidates from which firms can fill their job vacancies. This effect is particularly strong in professional services and high technology sectors, where skills requirements can be highly specialized and hence, where the value of a job match can increase significantly with the size and quality of the applicant pool.

In the context of the GTHA, the additional labour income due to increased labour supply and a better matching of workers and job vacancies would likely be significant for a major transit

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costs (including delays), but also any changes in the quality of transportation services (e.g. journey comfort within public transit vehicles and the ease of interchanges between different trip segments). Lower costs per unit of commuter transportation service should allow firms to pay lower wages in order to attract the same quantity and quality of labour.

[27] See AECOM "Update of Economic Evaluation Parameters: Working Paper on Methodology for Wider Economic Benefits" prepared for the Singapore Land Transportation Authority, p. 16.

[28] Gibbons, S. and S. Machin (2006). *Transport and Labour Market Linkages: Empirical Evidence, Implications for Policy and Scope for Further U.K. Research*. Background paper for the Eddington report to the Department for Transport. London: Department for Transport (U.K.).

investment program such as the Investment Strategy. Lower transportation costs can serve as a lubricant that enables workers to search for job opportunities across a wider geographic area of the GTHA and thereby facilitate a better matching of workers and jobs. These lower commute costs enable workers to locate the appropriate job vacancies more quickly. They can also enable workers to find vacancies that better match their skill set, thereby improving the productivity and wages associated with the job match. For example, improved public transit connectivity between downtown Toronto and the Mississauga employment hub at Airport Corporate Centre could encourage more downtown residents to seriously entertain job openings in Mississauga which they would not have otherwise considered. Only if workers are prepared to expand the catchment area within which they search for jobs can firms then benefit from a larger and higher quality labour pool that is associated with a larger catchment area. The wider catchment area would then result in firms finding better qualified candidates and workers achieving higher wages and lower periods of unemployment and underemployment.

4.5 Additionality of Wider Economic Benefits

This section examines which of the above impacts can be considered incremental or additional to the transportation user benefits that are at the heart of a standard cost-benefit appraisal. The main principle here is that the valuation of user benefits in traditional cost-benefit analysis captures all the benefits which are internal to the transportation users (i.e. all the impacts incorporated in the end user prices, be they for passengers or businesses). The external impacts or externalities are not automatically included and must be addressed explicitly, as in the case of environmental, safety and congestion costs.

In the case of agglomeration economies, these are by definition additional to the impacts estimated in conventional cost-benefit analysis because the productivity impacts from greater interactions in the input, output, and labour markets are not fully captured by the users which benefit from the generalized transportation costs savings. In fact, agglomeration economies refers to the externalities component of the benefits which arise from increased interactions in the three markets noted above.

The productivity gains resulting from increased competition – including the output effects as well as any impact on the level of competition in product markets – are both fully incremental to the impacts in conventional benefit cost analysis.

The additionality of the changes in labour market behaviour are a little trickier to establish. All the changes in labour market behaviour can be represented in terms of higher labour income – regardless of whether it is due to increased labour supply or to better matching of workers and job vacancies. The net wage component of the additional labour income (i.e. labour income net of all income and payroll taxes paid) is already captured in the conventional cost-benefit analysis, because the workers capture this part of the benefit. What they do not capture is the tax wedge – the portion of the additional gross labour income which goes to income and payroll taxes. This is the portion that is incremental to the conventional cost-benefit appraisal and can represent a significant benefit resulting from the changes in labour market behaviour.

This relationship between conventional cost-benefit analysis and the wider economic benefits is represented in Figure 3 below. It shows that conventional cost-benefit analysis captures the four following components:

- reductions in business costs associated with improved transportation for freight and business trips
- user benefits that are not part of business costs (these are called “non-work related user benefits” associated with commuter and leisure trips)

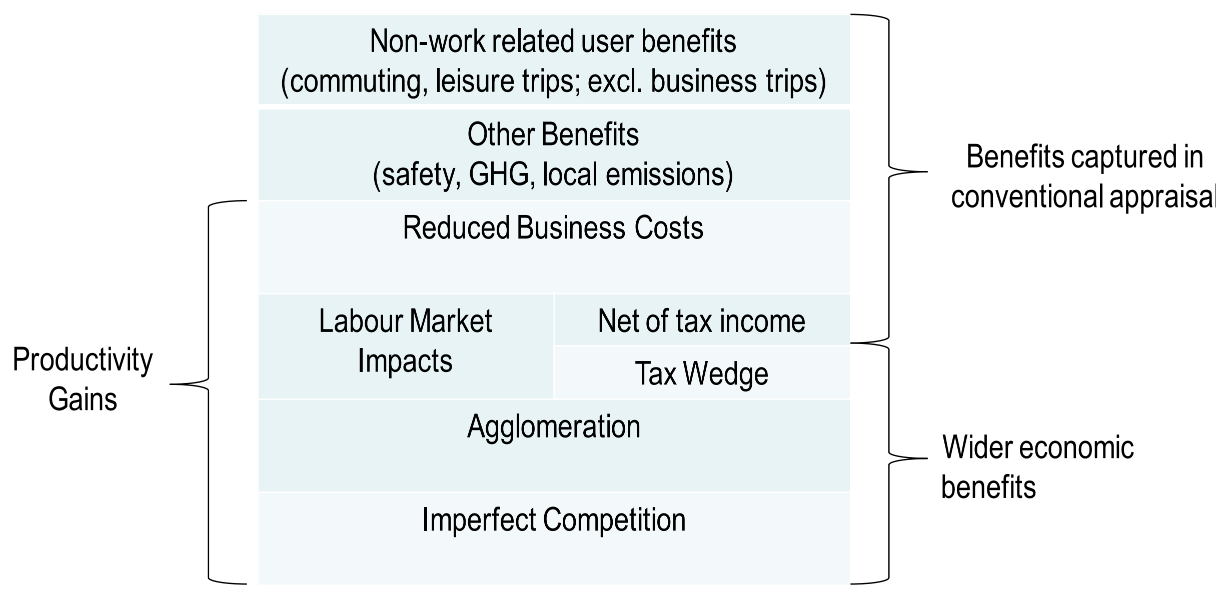
- other benefits, notably safety and environmental impacts, and
- the net of tax component of additional labour income[29]

The wider economic benefits which are incremental to the conventional cost benefit results are illustrated as three effects:

- agglomeration economies discussed in section 4.1 above
- imperfect competition, discussed in sections 4.2 and 4.3 above, and
- the taxes paid on the additional labour income arising from the project (i.e. "tax wedge")

It is also worth noting that not all the results of a conventional cost-benefit analysis represent productivity gains for the economy. In fact, only the reductions in business costs (and the additional labour income) represent productivity gains. Non-work related user benefits and other benefits are not treated as productivity gains, because they do not translate into cost reductions for businesses.[30] However, all the wider economic impacts represent productivity gains, which can take the form of increased output or reduced costs.

Figure 3: Relationship Between Conventional Benefit-Cost Analysis and Wider Economic Benefits



Source: Adapted from AECOM "Update of Economic Evaluation Parameters: Working Paper on Methodology for Wider Economic Benefits" Singapore Land Transportation Authority, p. 30.

[29] Note that this does not refer to the additional labour income resulting from the economic impacts of construction and operations activities. The latter impacts do not represent productivity gains.
[30] This does not mean that non-work related user benefits are any less important than reduced costs or other productivity impacts. It only means that some user benefits show up in GDP (i.e. the productivity gains), while other benefits show up in economic welfare measures (e.g. non-work related user benefits).

5. Other Socio-Economic and Environmental Impacts

This section identifies several other socio-economic impacts which are sometimes mentioned in the context of transportation projects and reviews the extent to which these can be quantified, valued in monetary terms, and whether or not they are considered incremental to the results of conventional cost-benefit analyses. These impacts include changes in land use, land (and development property) value uplifts, other environmental impacts (e.g. impacts on living organisms, also known as biodiversity) and other changes in the quality of life, including changes in the distribution of income and wealth.

Transportation professionals often highlight the potential of higher-capacity public transit projects (e.g. light or heavy rail projects) to transform land-uses in the areas near the new or affected stations. This area of transportation planning is known as "transit-oriented development". However, the changes in land use enabled by public transit projects are seldom factored explicitly into cost-benefit analysis. For example, in GGH model simulations of changes in travel behaviour resulting from any project or set of projects, the land use and employment inputs for each traffic zone are usually assumed to remain the same between the base case and the scenario under evaluation. In fact, even the calculation of agglomeration economies, as stipulated in the UK Department for Transport guidance, stipulates that land use and employment should remain unchanged between the base case and the scenario under evaluation, although it allows for sensitivity analyses where land use and employment are allowed to vary.[31] Perhaps part of the reason for this approach is that analysts have not identified a satisfactory method for estimating the incremental impact of any land use changes within the relevant area covered by the transportation network. For example, even if land uses change in the vicinity of a new fixed guideway transit project and these changes support higher employment levels in the relevant traffic zones, it is unclear if all the additional employment in the affected zones represents a redistribution from other traffic zones in the same urban area; nor is it clear which other traffic zones may experience a decline in employment as a result of the shift in employment to the higher-density traffic zones. Without identifying the incremental impact of changes in land use, these changes cannot be integrated into transportation network modelling without leading to potential double-counting of the cost-benefit results.

Notwithstanding the difficulty of estimating the incremental impact of changes in land use enabled by transit-oriented investments, these land use changes will tend to contribute to the higher residential and employment densities in the vicinity of stations, which in turn may reduce pressures for urban sprawl and assist in the preservation of open or green spaces in the region. The extent to which higher density developments in the vicinity of transit stations helps mitigate urban sprawl in the rest of the region would depend on supportive land use decisions not only in the vicinity of transit stations but also in the region as whole.

To the extent that transportation infrastructure investments result in a more integrated transportation system and in the kinds of changes in land use discussed above, this can also help reconnect communities with their surrounding areas and support the creation of vibrant public spaces which add to the vitality of the surrounding community.[32]

Land value uplift is another area of analysis which has been treated separately from cost benefit

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[31] See section 2.3 of DfT "The Wider Impacts Sub-Objective: TAG Unit 3.5.14" September 2009.

[32] These socio-economic effects have been emphasized in the literature on "Complete Communities". See http://www.completecommunities.ca/index.php?option=com_content&view=article&id=55:integrated-transportation-system&catid=34:principle-descriptions&Itemid=55 for a description of Complete Communities.

analyses of transportation projects. It is well established that high-capacity transit projects can lead to substantial increases in the value of land and property where inhabitants benefit from increased accessibility to other destinations.[33] However, these higher values are thought to result from the propagation of the time and cost savings which accrue to the affected transportation users. In other words, these users essentially “spend” the accrued time and cost savings on higher property values in the areas that benefit from the increased accessibility. This means that these property value uplifts cannot be considered benefits which are incremental to the results from conventional cost benefit analysis. Hence, the land value uplift can be considered an important description of the impacts of transportation projects, but the impacts cannot be treated as incremental – or at least not in their entirety. For this reason, land value uplift is usually discussed in the Social Community Account of the Multiple Account Evaluation approach used by Metrolinx and other transit agencies in Canada.

Other environmental impacts that may not be explicitly addressed in the Metrolinx MAE framework include the impact of transportation projects and climate change in particular on biodiversity, or the range of living organisms and ecosystems that form the natural resources support for humans. The challenge here lies in quantifying the damage of climate change and air pollutants due to transportation projects on biodiversity and valuing the damage in monetary terms. While considerable research has already been done in this area,[34] there remains more work to be done to incorporate monetary values of the damage to biodiversity (or the savings from averted damage) into the results of cost-benefit analysis. But there is no question that the biodiversity impacts are incremental and can be added to the cost-benefit and wider economic impact results. The monetary valuations of these damages are non-market valuations typically based on the willingness to accept compensation for foregoing these public goods. This differs from the concept of the willingness to pay for a good (or service), which is used to develop unit values of time used in cost-benefit analysis.

Other socio-economic impacts which have been noted in the literature, particularly in relation to climate change impacts, include various “changes in the quality of life, including a need to migrate, conflict over resources, cultural diversity, loss of cultural heritage sites, etc”.[35] These impacts are also incremental, but it is unclear whether or not the value of any of these impacts has been incorporated in the unit costs for GGH emissions.

Other impacts of interest include any changes in the distribution of income and wealth. The general presumption has been that the impacts of major transportation projects on income distribution may be marginal or de minimus. However, there has been some research which has examined the distributional impacts of certain revenue tools such as road user charges.[36] However, these impacts can only be examined alongside rather than integrated with cost-benefit analysis, since there is no widely accepted measure for valuing distributional changes.

[33] For example, it has been estimated that a new commuter rail tunnel to Midtown Manhattan could add US $16 billion to home values within two miles of NJ Transit train stations. See Regional Plan Association *The ARC Effect: How better transit boosts home values and local economies*, August 2010.
[34] See Annex 2 of A. Zhang et. al. *Towards Estimating the Social and Environmental Costs of Transportation in Canada*, November 2004 for a review of the literature on transportation and biodiversity.
[35] Zhang et al (2004): 388.
[36] Graham, D.J., Glaister, S et. al. “Testing for the Distributional Effects of National Road User Charging” *International Journal of Sustainable Transportation*, 2007.