THE ECONOMIC BENEFITS OF PUBLIC INFRASTRUCTURE SPENDING IN ONTARIO

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About this Study

This report was prepared for the Ontario Ministry of Economic Development and Growth, the Ontario Ministry of Infrastructure, and the Ontario Ministry of Finance by The Centre for Spatial Economics (C_4SE). The Ministry of Economic Development and Growth along with the Ministries of Finance, Infrastructure and the Treasury Board Secretariat share responsibility for implementing and assessing the Province of Ontario's 10-year infrastructure plan presented in Budget 2016.

The analysis estimates the economic benefits of the Province's 10-year infrastructure plan using the C_4SE's provincial economic modeling system. Results are presented in terms of the plan's impacts upon GDP, employment, government revenues and deficits over time. Spending multipliers and return on investment statistics are generated to provide summary measures of the benefits to Ontario residents and taxpayers. The results demonstrate the benefits of public funding for infrastructure where public capital can play an important role in contributing to investment-led economic expansions, and improving the productivity and competitiveness of private businesses in Ontario.

The report was conducted by Robin Somerville, Director, of the Centre for Spatial Economics (C_4SE). The C_4SE monitors, analyzes and forecasts economic and demographic change throughout Canada at virtually all levels of geography. It also prepares customized studies on the economic, industrial and community impacts of various fiscal and other policy changes, and develops customized impact and projection models for in-house client use. The C_4SE provides economic models, analysis and forecasts to nine provincial and territorial governments across Canada. For more information please go to www.c4se.com.

Acknowledgements

The author would like to acknowledge and thank the staff of the Ontario Ministries of Economic Development and Growth, Finance, Infrastructure and Transportation for their advice and feedback given during the writing process. Their input contributed to both the scope and quality of the paper. The author would also like to thank Wulong Gu and Ryan Macdonald of Statistics Canada for their insight into the contribution of public capital to productivity growth in Canada. The author, of course, assumes full responsibility for any shortcomings.

Executive Summary

This report provides estimates of the economic benefits of the Province's 10-year, $140 billion public infrastructure spending plan. The government's plan lays the foundation for future economic growth and prosperity in this province. The benefits from a public infrastructure program arise from the direct program spending, largely on construction, but then extend beyond this direct impact. Public capital also promotes long-term economic growth and productivity by reducing costs for private businesses; providing a compelling case for public funding of this capital.

The benefits of this public infrastructure spending program include the following:

- In the short-run, gross domestic product (GDP) rises $0.91 per dollar of spending, 4.7 jobs are generated per million dollars spent and $0.27 of each dollar spent by government is recovered in additional Ontario and federal and government revenues,
- Over the long-term, the discounted present value of GDP generated per dollar of public infrastructure spending (ROI) lies between $3.06 and $5.98,
- Businesses are more productive and competitive in international markets, and private sector investment rises,
- Real wages rise, providing a higher standard of living.

Table 1[1]

Ontario Public Infrastructure Spending: Summary of Benefits			
	Short-run Total Impact Multiplier	Long-run Return on Investment (2.5% discount rate)	
		Half Benefits Case	Full Benefits Case
GDP per $ of spending	0.91	3.06	5.98
Non-residential investment per $ of spending	1.14	1.50	2.00
Jobs per $million of spending	4.7	9.4	17.7
Ontario & federal gov't revenue per $ of spending	0.27	0.45	0.88
Ontario gov't revenue per $ of spending	0.13	0.25	0.47

Productive public infrastructure reduces costs for private businesses primarily through enhanced transportation networks and reliable water and waste-water management – boosting real GDP in the long-run by up to $6 per dollar spent – so that a compelling case can be made for public funding of this capital. The C_4SE believes that the full benefits case results, based on the cost-savings benefits to private business estimated by Harchaoui and Tarkhani (2003), are credible and represent the benefits that should accrue from spending on public infrastructure. But there is a risk that a large infrastructure program could yield lower benefits so that the half benefits case provides a prudent lower-bound to the analysis.

[1] The short-run impact multipliers are the average of the full and half benefits case scenario impacts.

Study Methodology

The analysis consists of three scenarios constructed using the C_4SE's provincial economic modeling system which is a multi-region, multi-sector, dynamic stochastic general equilibrium model of Canada and its provinces. The **baseline scenario** is set as a counterfactual and assumes that the Ontario government does not invest in the ten-year infrastructure plan. This baseline scenario is the benchmark against which each of the other scenarios is compared. The other two scenarios reflect the same short-term direct economic activity arising from the Province's 10-year, $140 billion public infrastructure spending program but have differing long-term impacts. The long-term impacts from the **half** and **full benefits case** scenarios assume respectively that the new public infrastructure provides either half or all of the cost-savings benefits to private business estimated by the research of Harchaoui and Tarkhani (2003).

The increase in public capital can also help achieve something else that has eluded policy makers in Canada over the last few years: gains in private sector investment spending. A public infrastructure program boosts private investment in both the near and long-term and can, therefore, play an important role in contributing to an investment-led economic expansion.

The results reported in this study are somewhat conservative relative to previous reports that have assessed the benefits of public infrastructure spending in Ontario but are generous when compared against analysis conducted in the US for infrastructure spending in that country. Like other reports, this study only quantifies some of the possible benefits from spending on public infrastructure. The benefits are limited to those from the actual or direct spending and the long-term benefits to business in terms of reduced costs from the public capital. But public spending on these assets is also required to achieve other social objectives that have not been captured or quantified in this analysis. These benefits include those to households from lower transportation and congestion costs, improved business networking opportunities, reductions in pollution and greenhouse gases, and societal gains from education, health care and other public assets.

In closing, this study also provides a cautionary tale for policy analysts. The costs of neglecting our public infrastructure are not zero. As noted by Infrastructure Canada (2011), allowing our public infrastructure to continue to decay imposes costs of at least equal but opposite consequence to the benefits estimated in this study. The competitiveness of private businesses in Ontario is tied to the quality of our public assets, especially given the shortfall of infrastructure investment in previous decades. Therefore, a significant and sustained public infrastructure spending initiative is required if households and businesses are to continue to enjoy a high standard of living.

Ontario's 10-year Infrastructure Spending Plan

In its 2017 Long-Term Infrastructure Plan Update, the Ontario government presents its 10-year, $140 billion public infrastructure spending plan to renew the province's infrastructure and improve local and regional public transit systems. Table 2 shows plan spending over the 2016 to 2025 period (referred to as the 'Plan Spending period' in this report). Plan spending is strongest in the third through fifth fiscal years (2018 to 2020) and moderates towards the end of the 10-year period.

Table 2

Ontario's 10-Year Infrastructure Spending Plan													
Millions of Dollars	***2014-15 Actuals***	***2015-16 Actuals***	***2016-17***	***2017-18***	***2018-19***	***2019-20***	***2020-21***	***2021-22***	***2022-23***	***2023-24***	***2024-25***	***2025-26***	***10-Year Total***
Public Transit	3,554	3,967	5,381	6,632	8,053	8,528	7,656	6,742	4,983	3,378	2,112	1,807	55,272
Highways & Other Transportation *	2,323	2,372	2,919	3,163	3,248	3,340	2,947	2,582	2,287	2,047	1,966	1,946	26,445
Health	3,568	3,225	3,192	2,745	2,774	2,775	3,062	2,243	2,339	2,816	2,952	1,914	26,812
Education	1,833	1,590	2,561	1,932	1,865	1,808	1,686	1,558	1,434	1,432	1,432	1,396	17,104
Postsecondary	519	624	1,091	1,035	593	450	466	467	468	464	459	456	5,949
Justice	144	150	255	314	566	626	573	396	230	217	216	216	3,609
Social	231	267	814	353	243	183	68	54	52	51	51	51	1,920
Other **	645	556	1,184	1,299	1,936	2,071	1,935	2,072	2,647	3,555	1,680	1,676	20,055
Total Infrastructure Expenditure	12,817	12,751	17,396	17,474	19,279	19,779	18,393	16,113	14,440	13,960	10,869	9,463	157,166
Less Other Partner Funding & Federal Contributions	*1,661*	*1,931*	*3,240*	*2,498*	*2,331*	*1,357*	*1,481*	*1,300*	*1,337*	*1,349*	*1,293*	*1,214*	*17,400*
Total Provincial Expenditure	**11,156**	**10,820**	**14,156**	**14,975**	**16,947**	**18,422**	**16,912**	**14,812**	**13,103**	**12,611**	**9,576**	**8,249**	**139,763**

As of 2016 Ontario Economic Outlook and Fiscal Review. Figures are subject to change and may not add up due to rounding.
The infrastructure plan includes investments in Moving Ontario Forward for public transit, highways, and other priority infrastructure projects.
** Other transportation includes highway planning activities, property acquisition and other infrastructure programs.*
*** Other sector includes government administration, natural resouces, culture and tourism sectors.*
Note: Other Partner Funding & Federal Contributions refer to third-party investments in hospitals, colleges and schools, and unassigned federal contributions to provincial infrastructure investments.

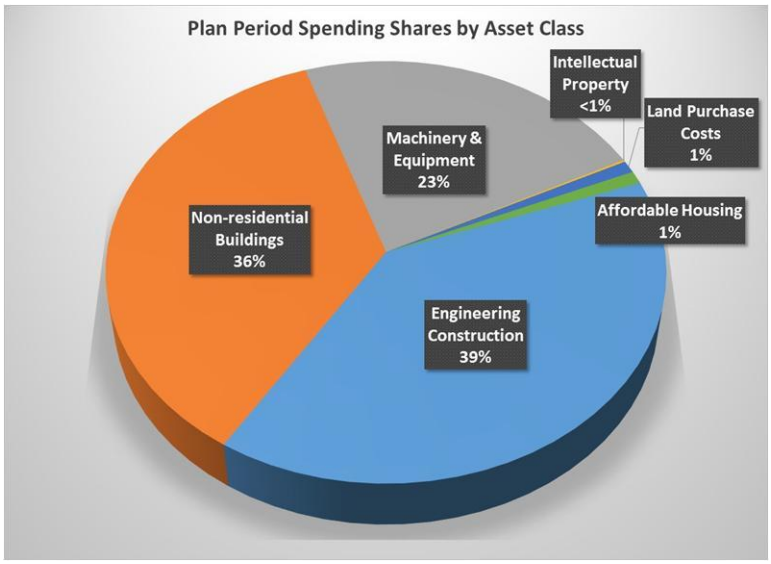

Figure 1

Based on detailed information provided by the Ontario Treasury Board Secretariat, the Plan Spending in Table 2 was allocated to the asset classes in the C_4SE's provincial economic modeling system: engineering construction, non-residential buildings, machinery and equipment, intellectual property,

affordable housing and land purchase costs.[2] Figure 1 shows that 40% of all spending is allocated to engineering infrastructure, followed by 36% for non-residential buildings and 23% for machinery and equipment. Spending on other infrastructure assets is under 2% of the total.

Economic Theory: Linking Public Infrastructure and Economic Performance

Economic studies over the last twenty-five years have consistently found a positive link between public infrastructure and productivity. While there are many critics of public spending that argue that it provides no benefits to society with media reports often citing examples of public infrastructure projects that provide little or no benefit to business or to the public these examples are, however, the exception.

Public capital, consisting of roads, bridges, sewer systems and water treatment facilities among other public infrastructure assets, constitutes a vital input for private sector production. Nonetheless, its impact on business sector productivity growth or total economy gross domestic product (GDP) is difficult to measure. Public capital in North America tends to be publicly owned so no markets exist for its output. There are no close substitutes for public capital in the private sector, thus making it infeasible to use private sector information as a proxy for the public sector. As a result, estimates of public capital's impact are not easily obtained.

In 1989, David Aschauer (1989) used production function estimates to ignite a debate about the role of public capital in private production, and its role in the productivity slowdown in the United States during the 1970s. Wylie (1996) adopted the approach taken by Aschauer to estimate the elasticity of public capital in Canada. Using a production function, and Canadian aggregate data from 1946 to 1991, he finds that government capital has a positive elasticity so that investing in public capital raises productivity and boosts economic growth. Wylie concludes by arguing that his results support the finding for the United States that public capital plays an important role in business sector output and productivity growth. For a variety of reasons, there have been many critics of these econometric studies. For example, the criticisms range from failing to account for non-stationarity in the data, to omitted variable bias and simultaneity bias. In addition, the magnitudes of the coefficient estimates – the benefits – are improbably large.

More recent empirical work replaces the production function with its dual: the cost function.[3] Nadiri and Mamuneas (1994) used the cost function approach to investigate the impact of public capital on the cost structure of US industries and obtained smaller, more credible, estimates of the benefits from public capital. Harchaoui and Tarkhani (2003) apply a similar approach to Nadiri and Mamuneas (1994) using Canadian data.

[2] While budgets are predicated on spending in nominal dollars, economic analysis recognizes that the value of future spending will be eroded by inflation. Restating the spending from Table 2 in terms of the value of a dollar spent in 2015 reduces the cumulative ten year spending total to $130 billion.

[3] In a production function, firms produce their output using various inputs (capital, labour, materials, etc.) so as to maximize their profits. A cost function has firms minimizing the cost of inputs to produce their output. The cost function is referred to as the dual of the production function because the two approaches yield the same outcome in terms of inputs and outputs.

Finally, an alternative non-parametric approach to productivity analysis is taken by Baldwin, Gu and Macdonald (2010) based on a growth accounting framework. It focuses on private sector inputs and outputs. Inputs that are difficult to measure or include, such as public capital, are folded into estimates of multifactor productivity (MFP). Critics of earlier studies that adopted this approach say that it is unclear how large an effect public capital has on productivity growth or whether the impact varies over time. The more recent research by Baldwin, Gu and Macdonald (2010), however, specifically incorporates public capital using the benefits estimated by Harchaoui and Tarkhani (2003) and others (Macdonald 2008).

Harchaoui and Tarkhani (2003) estimate the effects of public capital on business sector production costs, level of output, demand for labour, capital, and intermediate goods using Canadian data for 37 industries for the period 1961-2000 using a translog cost function. The authors found that an increase in public capital has an initial, direct productivity effect: it reduces the cost of producing a given level of output in almost all industries. This cost-reducing 'productivity effect' of public capital varies in magnitude across industries (see Appendix A for a table reproducing their results) with the largest benefits accruing to the transportation, wholesale, retail and other utility sectors. The economic impact of public capital on the various industries is not limited to the direct productivity effect. Cost reductions permit products to be sold at lower prices which can be expected to lead to higher sales and output growth. The authors refer to this as the 'output effect' of public capital.

The cost-reducing and output-expanding impacts of public capital affect the business sector's demand for labour, capital and intermediate inputs. The initial productivity effect of an increase in public capital results in a reduction in the demand for labour and intermediate inputs, but an increase in the demand for private capital in all industries. When industry production levels increase due to the 'output effect' of public capital, the change in the demand for labour and intermediate inputs is reduced while the demand for private capital increases. Thus, the 'output effect' of public capital reinforces the 'crowding in' of private capital formation so that public capital can be seen as having an important role in contributing to investment-led economic expansions, and implying that public capital is a complement to private capital.[4]

This paper uses the findings from Harchaoui and Tarkhani (2003) to estimate the economic benefits of the province's 10-year public infrastructure spending program using the C_4SE's provincial economic modeling system.[5] The next sections discuss the study methodology and assumptions, followed by the results. Results are presented in terms of impacts upon GDP, employment, government revenues and fiscal balances over time. Spending multipliers and return on investment statistics are generated to

[4] Critics of public spending contend that it can act as a substitute for private spending thus 'crowding out' private spending and reducing the overall impact of public spending. The 'crowding in' of private spending is the reverse of this phenomenon where private sector spending rises through the multiplier effect of public spending.

[5] Harchaoui and Tarkhani's (2003) results were used rather than those from Macdonald's (2008) more recent cost function estimation because their data allowed for the estimation of translog cost functions while limitations in Macdonald's data restricted him to a Cobb-Douglas approach. As a result, the estimated industry cost elasticities with respect to public capital - while similar in aggregate to those obtained by Harchaoui and Tarkhani - exhibited greater overall variability across industries.

provide summary measures of the results. The paper concludes with some observations based on the results.

Methodology and Assumptions

This section reviews the methodology and assumptions required to assess the benefits of public infrastructure spending in Ontario. The benefits of a public infrastructure program arise from the direct program spending and beyond, with public capital promoting economic growth and productivity.

Benefits to Private Industry

The private industry cost-savings elasticities estimated by Harchaoui and Tarkhani (2003) are used to reduce production costs by business sector in the C_4SE's provincial economic modeling system. A table of their elasticities of costs with respect to public capital by business sector is reproduced in Appendix A. The Province's infrastructure spending plan raises the stock of public infrastructure capital in Ontario by 59% above the levels in the baseline scenario in 2025. Without additional renewal spending after the Plan Spending period, the stock of public infrastructure would return to its baseline levels. Based on government estimates, average spending of $2.6 billion a year (measured in 2015 reference year dollars) is required to maintain the service levels of the new capital added during the Plan Spending period.[6] This study, therefore, assumes sustained provincial spending of that amount for the Post-plan period.

Harchaoui and Tarkhani's (2003) research focused on the cost-savings benefits of engineering capital. Ontario's Plan spending raises the stock of public sector engineering capital in the province by 58% in 2025. Ontario's infrastructure plan includes significant spending on local and regional public transit systems. Spending on machinery and equipment will boost the stock of public capital in the public transit sector by 144% over baseline levels in 2025. Spending on machinery and equipment for public transit is included as a benefit to private industry because of the widely acknowledged impact of transportation congestion on business costs. Enhanced public transit will lower commute times and reduce transportation costs, and help alleviate congestion which will benefit private businesses in Ontario. Including public transit machinery and equipment spending with public engineering (including that for public transit) yields an overall 59% increase in the stock of public capital which is used to determine private sector benefits: a 59% increase in the stock of public capital will reduce production costs by industry by 59 times the estimated cost elasticity.[7]

Spending on infrastructure projects takes time to complete and then further time before businesses can realize cost-savings from its benefits. To reflect this delay, the impact on industry costs is partially introduced into the C_4SE's model in the second year following the initial infrastructure spending with the cost-savings benefits continuing to accrue for another eight years before the benefits from that initial year's infrastructure spending are fully realized. The cost-savings benefits for Plan Spending in subsequent years is similarly accrued over time. As a result, the cost-savings benefits from Plan Period

[6] This $2.6 billion annual average Post-plan expenditure is calculated using the historical average rate of renewal spending as a share of the current replacement value of Ontario's existing public capital stock, multiplied by the additional public capital stock during the Province's 2016 to 2025 infrastructure plan spending period.
[7] Harchaoui and Tarkhani's (2003) research was based on all infrastructure spending across Canada including renewal spending as well as spending on new projects.

Spending continue to rise into the Post-plan period as the benefits from earlier year's spending is realized.

Finally, it is important to note that the use of public capital by one industry is assumed not to preclude or reduce the value of its use by any other industry.[8]

A Scenario-based Approach to Modeling Uncertainty

The private industry cost-savings elasticities estimated by Harchaoui and Tarkhani (2003) are considered plausible by many economists. Their work corrects the methodological concerns of earlier studies and produces elasticities that are significantly smaller than those from earlier empirical studies. There is still, however, debate and uncertainty over the precise level of cost-savings benefit conferred to private industry from public capital.

Uncertainty is addressed through a set of scenarios. The first scenario, referred to as the **baseline scenario**, does not include any public infrastructure spending. This is the benchmark against which each of the other shock scenarios is compared. A pair of scenarios are provided to evaluate the range of benefits of lower industry costs: the **full benefits case** and the **half benefits case**. [9] The **half benefits case** scenario halves Harchaoui and Tarkhani's (2003) business industry cost elasticities and reflects the possibility that such a large spending program, while addressing many vital infrastructure needs, may also include a number of projects of lower economic necessity or value. Economists refer to this phenomenon as 'diminishing marginal return on investment.' The **full benefits case** is based on the full value of the estimated cost elasticities.[10]

[8] This study assumes that current government spending (excluding debt service charges) is not directly affected by infrastructure spending. For example, improvements or additions to the stock of institutional buildings are assumed to either replace decommissioned buildings or to meet anticipated increases in demand arising from changes in population. As a result, employment in public administration, public education or health care rises - or falls - based on changes in provincial population-based needs and not in direct response to the construction of new facilities.

[9] A third shock scenario is the **zero benefits case** which assumes that public infrastructure provides no benefit to private business. The results from this scenario are an extreme case and do not represent a likely outcome; so they are not shown in this report.

[10] Harchaoui and Tarkhani's (2003) estimated elasticities reflect the full historical portfolio of infrastructure projects: successful or otherwise. It is, however, possible that the cost-savings benefits could exceed those reported in the full benefits case if Plan spending is devoted to more productive assets.

Results: Total Economic Impact

This section of the report presents the total economic impact of the public infrastructure spending program described in the previous section. The analysis is conducted using the C_4SE's provincial economic modeling system which is a multi-region, multi-sector, dynamic stochastic general equilibrium model of Canada and its provinces.[11]

The analysis consists of three scenarios. The **baseline scenario** does not include Ontario's public infrastructure plan spending and is the benchmark against which each of the other scenarios is compared. The other two scenarios reflect changes in economic activity arising from the provincial infrastructure spending program. The two shock scenarios are the **half** and **full benefits cases** which assume respectively that the new public infrastructure provides either half or all the cost-savings benefits to private business estimated by Harchaoui and Tarkhani (2003).

Table 3

Ontario Public Infrastructure Spending: Summary of Economic Impacts				
	Average annual difference from baseline		Average annual percent difference from baseline	
	2016-2025	2026-2050	2016-2025	2026-2050
GDP (millions of 2015 dollars)				
Half Benefits to Private Business	10,877	27,078	1.3%	2.5%
Full Benefits to Private Business	12,323	57,533	1.5%	5.3%
Employment (thousands)				
Half Benefits to Private Business	59.0	66.7	0.8%	0.8%
Full Benefits to Private Business	61.2	150.5	0.9%	1.9%
Non-Residential Fixed Investment (millions of 2015 dollars)				
Half Benefits to Private Business	14,317	7,029	18.1%	5.8%
Full Benefits to Private Business	14,716	12,103	18.6%	10.0%

The results are conducted under the assumption that ongoing provincial public renewal spending in the Post-plan period is sufficient to maintain the service levels of infrastructure attained in 2025 at the end of the 10-year Plan Spending period. This spending ensures that the boost to competitiveness for businesses in the province from the initial investment in infrastructure does not diminish over time. Without this Post-plan spending, the stock of public capital affecting business sector costs would decline — as would their estimated cost-savings benefits. Incorporating a permanent Post-plan level of public renewal spending has fiscal implications over the long term, but it also provides a perspective of the long-run benefits arising from a new, stable, higher level of public infrastructure in the province.

Table 3 summarizes the economic benefits from these scenarios by comparing activity in the two public infrastructure spending scenarios against the baseline scenario.

The total impacts for the two benefits case scenarios in Table 3 include the **direct** increase in public infrastructure spending, plus the **indirect** impact on Ontario suppliers to the construction companies of

[11] The model is described in more detail in Appendix B, which also provides a table of results for each shock scenario relative to the baseline scenario that includes additional measures not shown in the charts in this section.

everything from office supplies to construction equipment used in the construction process, plus the **induced** impacts. Induced impacts include the impact on the economy from employees (at the direct and indirect level of impact) spending their incomes, and then the income that process generates being re-spent by its recipients. The provincial economic modeling system also considers changes in business investment spending arising from the shifts in the economy, changes in wages, prices, interest and exchange rates, and changes in population as people move based on prevailing economic conditions. These factors combine to ensure that the total impact is, in the long-run, larger than the direct increase in spending.

The impact on GDP, measured in millions of 2015 dollars, during the Plan Spending period (2016 to 2025) is $10.9 billion for the half benefits case or 1.3% a year on average higher than in the baseline scenario, and is up to $12.3 billion (or 1.5%) higher in the full benefits case. This pattern is the same for non-residential fixed investment over this period. It is worth noting that the average annual increase in fixed non-residential investment is higher than the public infrastructure program spending of $13.0 billion a year (expressed in 2015 dollars) in both the full and half benefits case scenarios. This supports Harchaoui and Tarkhani's (2003) finding that public capital spending raises private spending on new capital. The increase in average annual employment relative to the baseline is between 59 and 61 thousand for the two shock scenarios as higher output supports gains in employment.

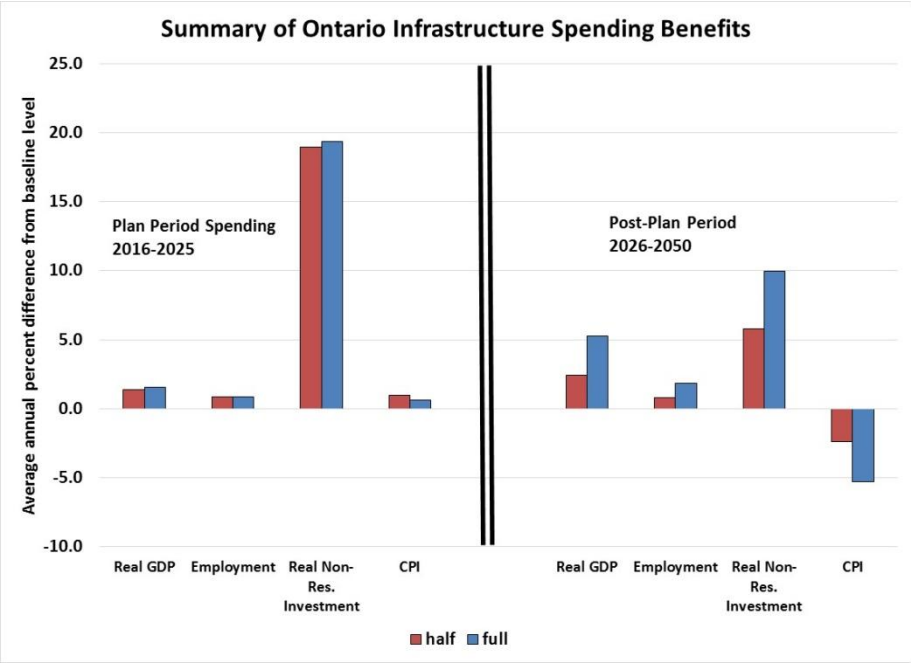

Figure 2

After the infrastructure program ends, reductions in business costs incorporated in the half and full benefits cases lead to average increases in GDP relative to the baseline of between $27.1 and $57.5 billion a year. The long-run impact on non-residential investment spending follows the same pattern as GDP. The half benefits case raises average annual investment by $7.0 billion relative to the baseline while the full benefits case increases it by $12.1 billion. Finally, the long-run impact on employment

varies between an average annual increase in jobs of 67,000 and 150,000 as higher economic activity raises the demand for labour relative to the baseline.

Figure 2 to Figure 6 provide a summary of the impacts on select key economic measures for each scenario relative to the baseline over the Plan Period Spending phase and over the 2026-2050 long-run period.

Figure 2 illustrates the percent difference from the baseline levels for GDP, employment and non-residential fixed investment from Table 3. It also includes the impact on the level of the consumer price index (CPI) relative to the baseline.[12] In the Plan Period Spending phase, the CPI is slightly higher than the baseline in the shocks, but lower industry costs from higher productivity feed through to moderate the increase in the CPI in the full benefits case. The difference in CPI impacts across shock scenarios becomes more pronounced over the long-run as the benefits from lower industry costs reduce prices throughout the economy.

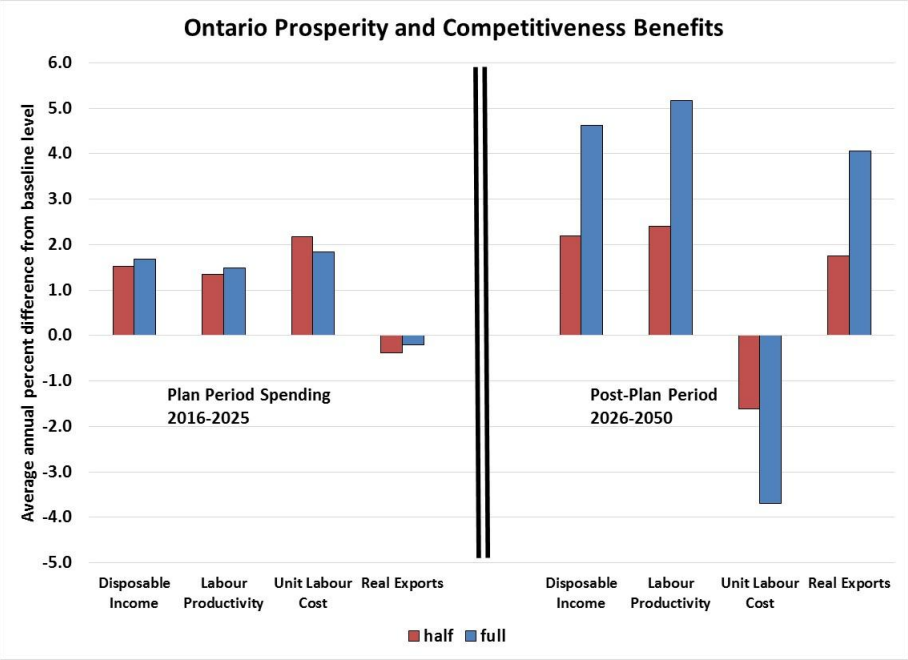

Figure 3

The impact on prosperity and competitiveness measures is shown in Figure 3. The average annual percent increase, relative to the baseline, in real per capita disposable income is similar for the shock scenarios during the Plan Period Spending phase but increases significantly in the long-run: up to 4.6% for the full benefits case scenario. The increase in disposable income reflects gains in average annual labour productivity (output per hour worked) which is, in turn, driven higher in the long-run when industry costs fall due to the increase in public infrastructure.

[12] The reader should note that this shows the difference in the level of prices from the baseline to the shock scenario and not the difference in the inflation rates between scenarios.

Unit labour costs measure the value of labour, in nominal dollars, required to produce a unit of real output and are often used to assess competitiveness. Higher unit labour costs make it harder for goods and services produced in a region to compete against imports from other regions or to find export opportunities in those markets. Increased economic activity and higher employment push wages up during the Plan Period Spending phase which raises unit labour costs in both shock scenarios. The increase in unit labour costs is higher for the half benefits case than for the full benefits case as less of the cost-savings benefits from public infrastructure are realized by private business. Reductions in industry costs have a significant impact on unit labour costs over the long-run due to lower nominal wages and increased productivity.

Shifts in competitiveness influence both exports and imports. Higher unit labour costs cause real exports to fall and real imports to rise, relative to the baseline, during the Plan Period Spending phase. The reverse is true in the long-run as real exports rise for both the full and half benefits case scenarios. Imports rise, relative to the baseline, in both the short and long-term for both scenarios, driven higher by increased economic activity in Ontario.

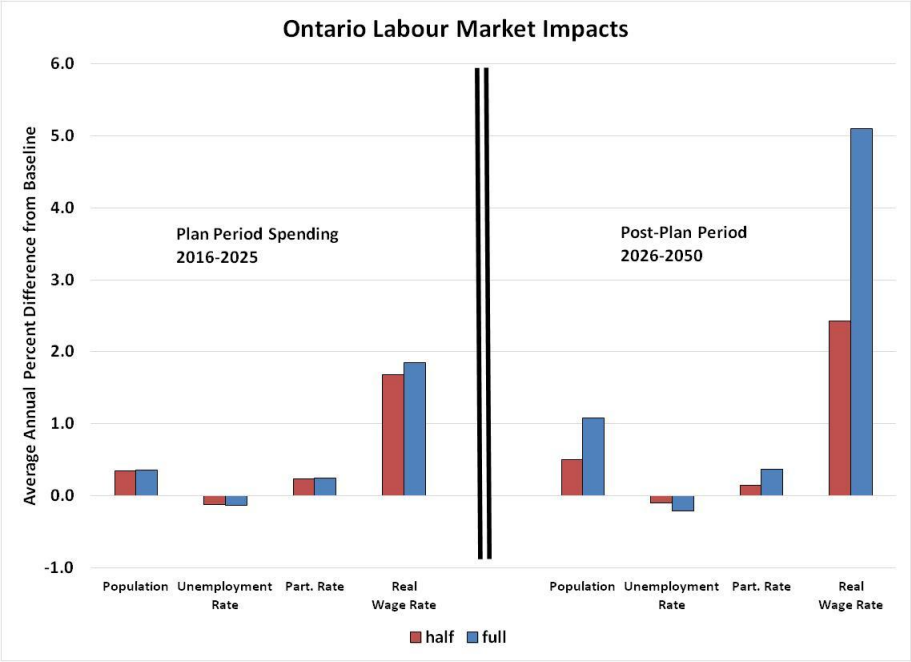

Figure 4

Many of the changes in the economy can be understood by taking a closer look at the impact of public infrastructure spending on the labour market (see Figure 4). The lower unemployment rate raises real wages during the Plan Spending period and encourages higher labour force participation and net in-migration to the province. These effects persist in the long-term. Higher productivity boosts real wages significantly in the half and full benefits case scenarios relative to the baseline in the Post-plan Spending period which raises labour force participation rates and population and reduces the unemployment rate.

The impact on government revenues, spending and fiscal balances[13] are summarized in Figure 5 and Figure 6 for the Provincial and federal government respectively. The impacts are expressed as the change, relative to the baseline, in billions of 2015 reference year dollars.

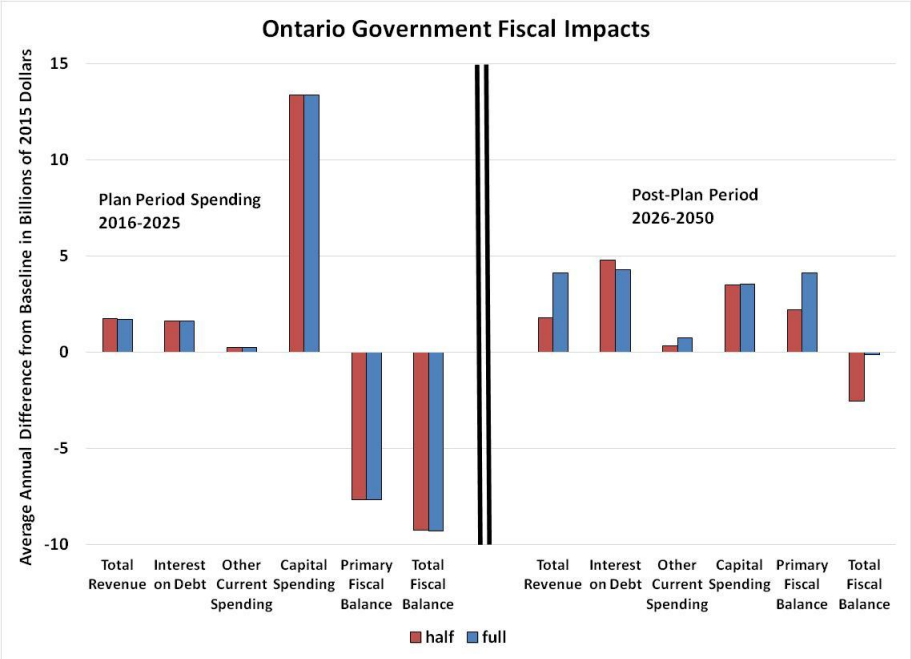

Figure 5

Figure 5 focuses on the provincial government. The increase in government revenues during the Plan Spending period is nearly the same as the increase in interest payments on the Province's debt. The impact on other current spending[14] is near zero while the change in capital spending directly reflects the Province's Plan spending. This analysis assumes Ontario's infrastructure spending is financed almost entirely through borrowing. As a result, higher interest payments mean that the $9.3 billion average decline in the Province's total fiscal balance relative to the baseline is greater than the deterioration in the primary fiscal balance.[15] The impact on the provincial government is hardly surprising as Plan spending generates just a fraction of the revenues of the raised expenditures. In addition, Ontario is essentially the sole contributor to the Plan, while the benefits are shared by all levels of government.

Over the long-term, Figure 5 shows the impact of the stronger economy on government revenues and the rise in interest payments on the Province's debt. Higher revenues in the full benefits case scenario

[13] The fiscal balance figures used in the C_4SE's provincial economic modeling system are based on Statistics Canada's National Income and Expenditure Accounts (NIEA) which differs from the Public Accounts (PA) basis figures reported by the Ontario government in the budget and other documents. Key differences between the two sets of accounts exist. The NIEA are reported on a calendar year basis while the PA are on a fiscal year basis, the NIEA treats capital expenditures on a modified accrual basis whereas the PA amortize capital spending, and the NIEA include various different budget items compared to the PA.

[14] Other current expenditures include current spending on goods and services, and transfers to persons, businesses and other levels of government. They do not include interest payments on government debt or capital spending.

[15] The primary fiscal balance excludes interest payments on public debt from the total fiscal balance.

help reduce interest costs on the public debt relative to the half benefits case scenario. Other current spending is little changed from baseline scenario levels while capital spending rises to reflect renewal spending required to maintain the Plan Spending Period's new public infrastructure. Ignoring interest payments, the Province's primary fiscal balance improves in both the full and half benefits case scenarios reflecting the long-run economic benefits of public infrastructure spending, but higher interest payments on the Province's debt lead to the fiscal balance deteriorating in the long-run; although the deterioration is very small in the full benefits case scenario.

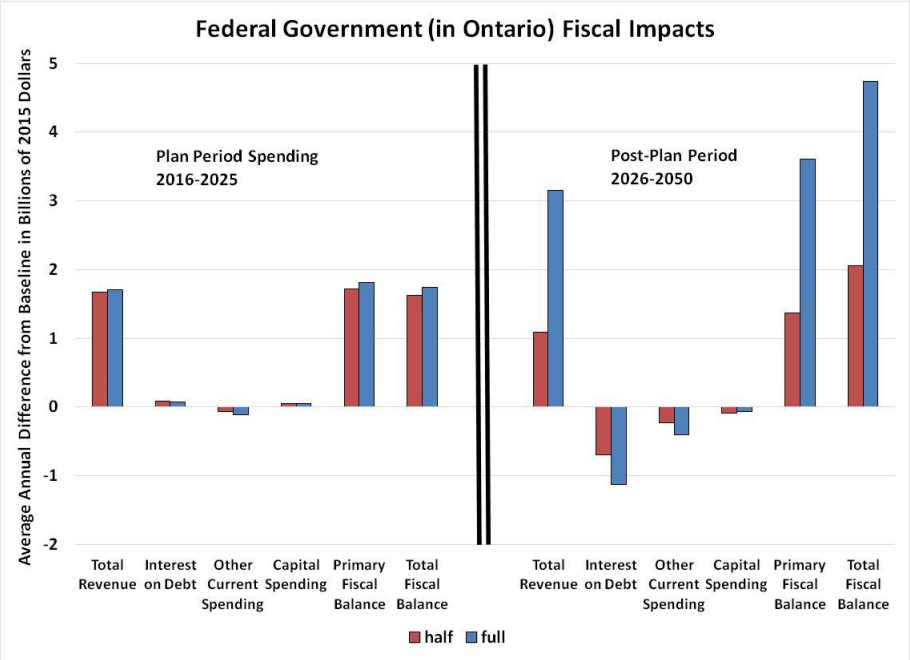

Figure 6

During the Plan Period Spending phase, federal government revenues in Ontario rise leading to an improvement in both the federal primary and total fiscal balances. Federal government spending on interest payments, other current spending and capital spending are near zero in this period. The federal balance in Ontario, therefore, improves over the period by an average of about $1.6 billion a year relative to the baseline scenario.

Federal government revenues in Ontario remain above baseline levels in the long-term, while there is little impact on other current spending and capital spending in either shock scenario. Higher revenues in Ontario help reduce the national debt, lowering Ontario's share of interest on that debt. As a result, the federal government balance improves by an average of between $2.1 and $4.7 billion a year relative to the baseline scenario.

The next section examines the results on a year-by-year basis so as to illustrate the dynamic properties of this analysis. This is followed by an examination of the impacts by industry sector. Finally, the results are summarized by a set of impact multipliers and returns on public investment statistics.

Dynamic Impacts

For ease of exposition, most of the results of the analysis in previous sections have been presented either in terms of the impacts over the Plan Spending period, or as an average of the Post-plan long-term impacts. The C_4SE's provincial economic modeling system does, however, produce results for each year of the analysis. The annual results are presented in this section to show the dynamic evolution of the economy in response to the increase in infrastructure investment spending and also to help illustrate different ways of interpreting impact analysis.

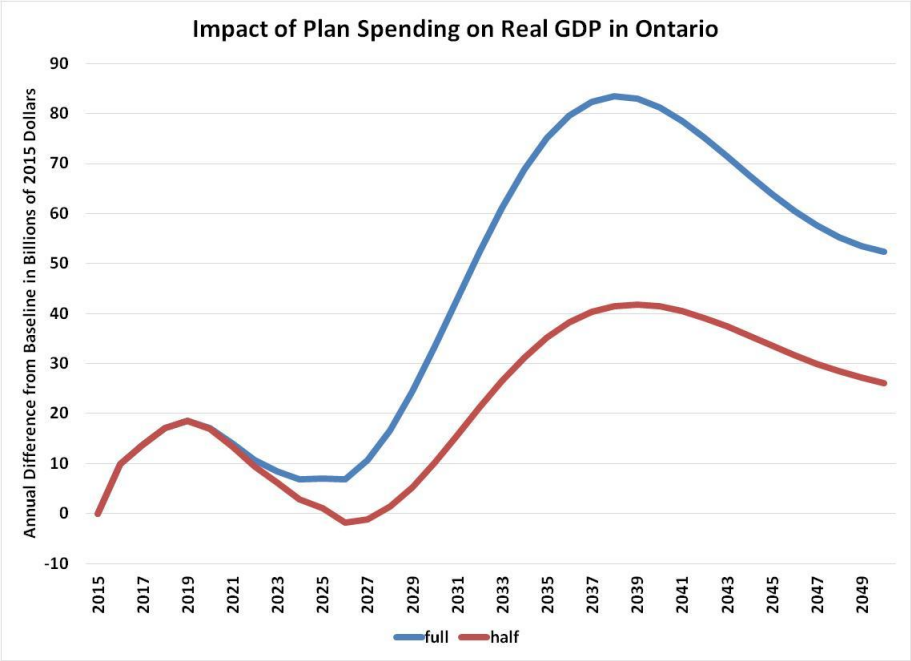

Figure 7

The level differences in real GDP from the baseline scenario are shown in Figure 7. The increase in real GDP during the Plan Spending period for the two benefits scenarios peaks at $18 billion in 2019 before the cost-savings benefits from public infrastructure start to drive economic output permanently higher than baseline levels: on average between $27 billion (2.4%) and $58 billion (5.2%) in the long-run for the two shock scenarios. The economic cycles seen in Figure 7 are caused by: (i) the slowdown in public infrastructure spending in the second half of the Plan Spending period; and (ii) the adjustment of the economy to changes in wages and prices arising from the more rapid growth due to the cost-savings benefits to private business from enhanced public infrastructure. The impacts on real GDP differ for each scenario as the cost-savings benefits from public infrastructure are gradually realized.

The impact on employment in Ontario is shown in Figure 8 and broadly echoes the impact on real GDP seen in Figure 7. The public infrastructure program raises employment by about 136,000 persons (1.9%) in 2019. The impact on employment is quite similar across the shock scenarios for most of the Plan Spending period and then diverges over the remainder of the simulation period. Long-term increases in

employment relative to the baseline are limited because the C_4SE's provincial economic modeling system assumes that wage rates adjust to return unemployment rates to their 'natural' rate.[16]

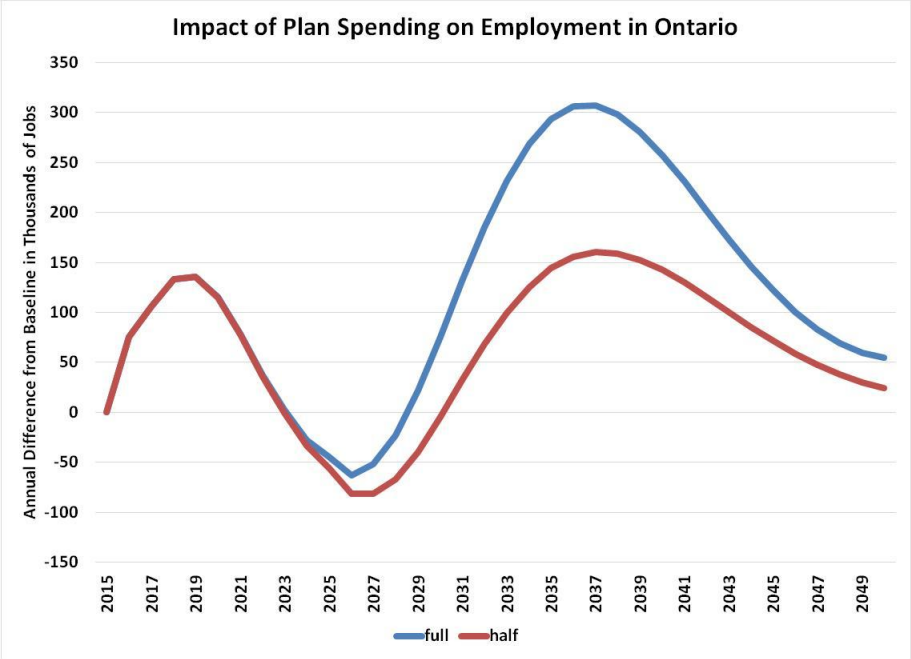

Figure 8

Industry Impacts

The impacts by industry are shown in Figure 9 and Figure 10. Figure 9 shows the average annual percent difference from the baseline level by sector for each of the public infrastructure spending scenarios versus the baseline over the Plan Spending period (2016-2025) while Figure 10 shows the impact over the balance of the projection period (2026-2050).

The construction industry is the principal beneficiary of the public infrastructure spending program over the Plan Spending period, with construction sector GDP 12% above baseline levels for each of the scenarios. The gains to other business sectors are generally around 1% to 2% but are weak for the primary sector and manufacturing. The weakness in these sectors is from trade as higher unit labour costs lower exports and raise imports. The gains for the public sector are well under 1% and are determined by changes in provincial population.

[16] The C_4SE's provincial economic modeling system ensures that the unemployment rate returns, over time, to its 'natural rate' (the 'natural unemployment rate' excludes unemployment due to cyclical activity in the economy). This adjustment process involves not only changes in the wage rate but also changes in labour migration as people move to regions with better employment opportunities. This process has several consequences for the economy. First, the change in wages required to help move the unemployment rate back to its natural rate is reduced when labour is mobile; and second, changes in population arising from labour migration introduce economic cycles into the model results as new residential housing, business investment and even public sector spending adjust to reflect higher, or lower, population levels.

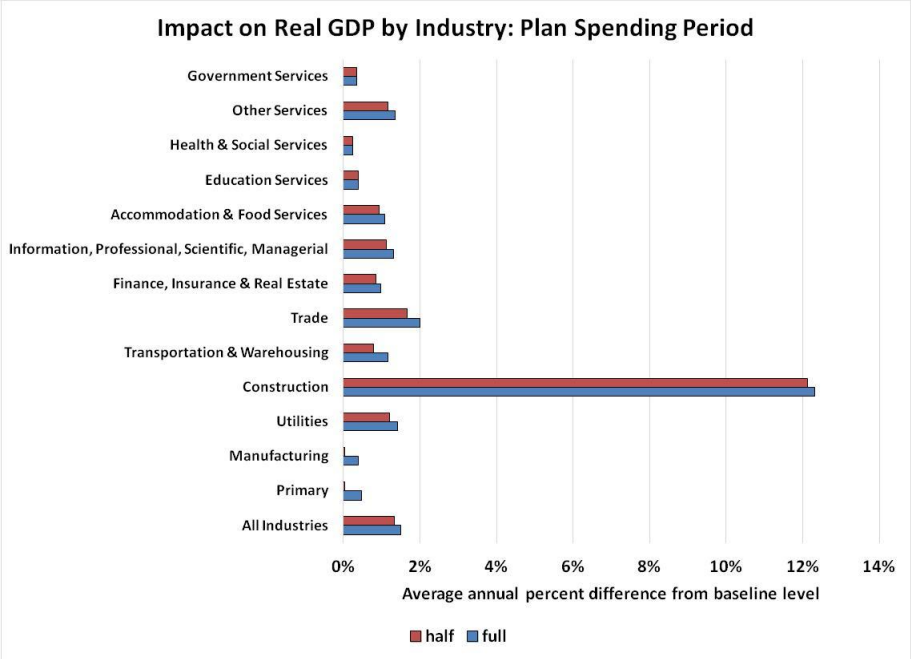

Figure 9

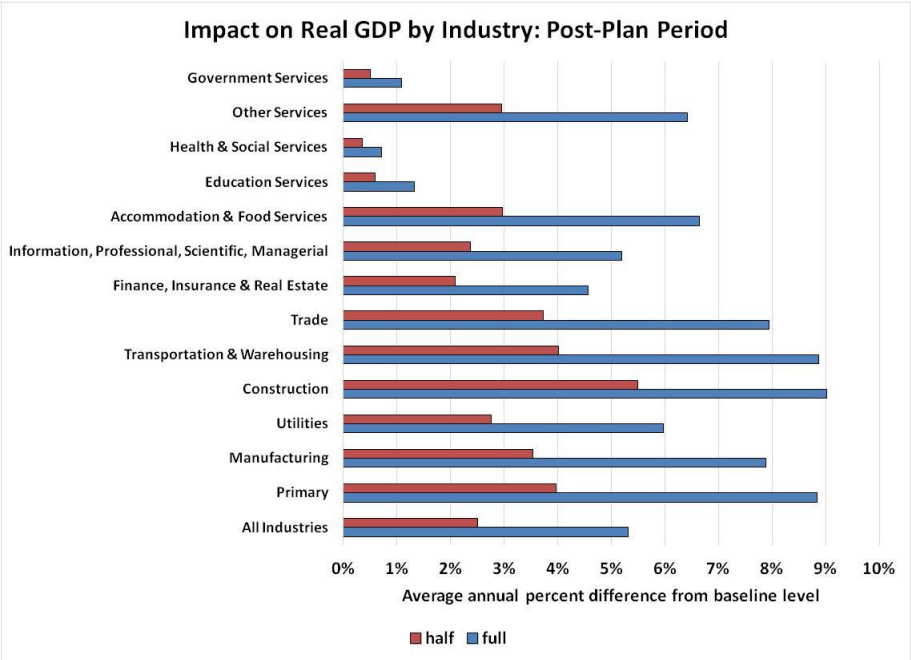

Figure 10

Over the long-term, all industries gain relative to the baseline in the full and half benefits case scenarios. The gains are strongest for private sector industries that benefit from the increase in competitiveness from public infrastructure. Gains for the public sector are limited by changes in provincial population.

Economic Multipliers and Return on Investment

Economic multipliers and return on investment measures are often used to summarize the economic benefits of public or private activities.[17] Economic multipliers are presented in Table 4 and measure the short-term benefit to the economy — in terms of GDP, jobs, investment or government revenue — of a dollar of public infrastructure spending. Return on investment statistics are generated to summarize the long-run benefits of public spending and are also presented in Table 4. The principal difference between the two types of statistics is that multipliers are a measure of contemporaneous benefit while return on investment statistics express the net present value of benefits over the long-term as a multiple of costs.

Short-run Multipliers

The GDP multiplier is generated by dividing the change in real GDP relative to the baseline for the Plan Spending period 2016 to 2025[18] by the change in public infrastructure spending (see Table 4). For GDP, the Plan Spending multiplier is 0.91. This means that the economy expands by $0.91 for every $1.00 spent on public infrastructure.[19]

Table 4

Ontario Public Infrastructure Spending: Summary of Benefits			
	Short-run Total Impact Multiplier	Long-run Return on Investment (2.5% discount rate)	
		Half Benefits Case	Full Benefits Case
GDP per $ of spending	0.91	3.06	5.98
Non-residential investment per $ of spending	1.14	1.50	2.00
Jobs per $million of spending	4.7	9.4	17.7
Ontario & federal gov't revenue per $ of spending	0.27	0.45	0.88
Ontario gov't revenue per $ of spending	0.13	0.25	0.47

The impact on employment is typically expressed in terms of jobs per million dollars spent on public infrastructure. The Plan Spending period employment multiplier is 4.7 jobs per million dollars.

The public and private non-residential investment multiplier is 1.14 and measures the extent to which investment in the private sector and, to a limited extent, other parts of the public sector expands in response to the increase in economic activity from the public infrastructure spending program. This measure's value of more than one provides evidence of the 'crowding-in' effect of public infrastructure spending where it encourages additional private investment.

[17] An economic multiplier is the factor by which the gains in one measure – such as GDP or employment – are greater than the factor (investment spending) that caused it. The return on investment is a performance measure used to evaluate the efficiency of an investment.

[18] The short-run multipliers shown in Table 4 are generated from the average of the full and half benefits case impacts. For ease of exposition, an average was used because there is little variation in these measures between the full and half benefits case scenarios.

[19] While the total value of spending exceeds the direct increase in spending, the total GDP generated may not. This is because GDP measures the value added to the economy by removing the value of intermediate inputs (goods or services produced by another business) and imports so as to avoid double counting. As a result, GDP multipliers may be more or less than one.

Combined Ontario and federal government revenue[20] rises $0.27 per $1.00 of Plan Period spending while Provincial government revenue rises $0.13 per dollar spent. As these multipliers or revenue recovery rates are less than one, the Ontario government finances the program by running higher deficits or lower surpluses.[21]

Long-run Return on Investment

The longer term benefits of public infrastructure spending are assessed through a Return on Investment (ROI) statistic. ROI calculations can be defined in a variety of ways. The denominator is the net present value of expenditure or investment over time associated with a particular outcome. The net present value of the outcome over the simulation period is the numerator. The benefit associated with a variety of different outcome measures can be assessed. The most common outcomes from economic benefit studies tend to be GDP, employment and government revenue.

Discount Rates

The future is uncertain; so people place more importance on what they have today relative to what they may have in the future. Uncertainty and potential risks rise as you look further into the future. This notion of "discounting" the future is used to express how much less someone would accept today in place of higher but uncertain future returns.

In the context of this analysis, the annual costs and benefits generated by the C_4SE's Provincial Economic Modeling system over the projection period are converted to current day values using a discount rate. In many cases the yield on long-term government bonds is used to represent the discount rate. This rate accounts for the risks from both inflation and uncertainty about the future. However, the economic measures considered in this report exclude the impacts of inflation so a lower real discount rate can be used. In this study a discount rate of 2.5% is used but higher uncertainty surrounding the potential benefits from public infrastructure may also warrant the use of a higher discount rate. The benefits based on higher discount rates do not materially affect the conclusions.

The costs and benefits in this study are assessed over the projection horizon in the C_4SE's Provincial Economic Modeling System (from 2016 to 2050). Arithmetically extending the projection horizon out beyond 2050 leads to stronger, positive results at all discount rates for the GDP, employment and government revenue ROI statistics. However, this alternate approach was not adopted because of rising uncertainty and the potential that global events or other, disruptive technologies could arise in future decades affecting the assumed long-term returns.

[20] Ontario government revenue includes all tax and non-tax sources of revenue. Combined Ontario and federal government revenues exclude inter-governmental transfers.

[21] In 2015, Ontario government revenue, excluding transfers from other levels of government, is just under 13% of GDP while combined Ontario and federal government revenues excluding transfers from other levels of government are about 27% of GDP. These average measures are slightly lower than the marginal rates implied in Table 4 which are 0.15 for Ontario government revenue and 0.30 for combined Ontario and federal government revenue.

The ROI statistics in this study show the net benefit to society from the public infrastructure spending program. The first ROI statistic shows the discounted value of GDP, measured in 2015 dollars, per dollar of funding (also expressed in 2015 dollars). The second statistic shows the discounted number of jobs per million dollars of spending. The final ROI statistics shows the number of dollars of additional federal (in Ontario) or combined provincial government revenue, expressed in 2015 dollars, per dollar spent.

Table 4 shows the ROI statistics associated with the full and half benefits public infrastructure spending scenarios. The analysis reveals that:

- The overall ROI is expressed in terms of discounted GDP divided by discounted spending to build and maintain the new public infrastructure. Discounting future costs and benefits by 2.5% yields a ROI of between $3.06 and $5.98 per dollar of spending for the half and full benefits cases respectively.
- A ROI can also be expressed in terms of jobs generated per $1 million of spending to build and maintain new public infrastructure. The full benefits case generates 18 jobs per $1 million of funding at a 2.5% discount rate but this falls to 9 jobs for the half benefits case.
- The return on public investment is expressed in terms of discounted government revenues divided by discounted Plan and Post-plan spending to build and maintain the new public infrastructure. Discounting future revenues and spending by 2.5% yields a combined Ontario and federal government revenue ROI of $0.88 per dollar of spending and $0.47 of Ontario government revenue per dollar of spending for the full benefits case. The ROI falls to $0.45 for combined government revenue and $0.25 for provincial government revenue for the half benefits case at a 2.5% discount rate.

A public infrastructure program does not 'pay for itself'. Over the long-term, the Ontario government will collect between $0.25 and $0.47 in revenue for every dollar it spends. When the revenue from the federal government is included, it comes closer with between $0.45 and $0.88 in revenue collected for every dollar spent by the Provincial government. The public infrastructure spending does, however, stimulate private sector investment and generate significant increases in the province's GDP and productivity.

Results in Relation to Other Studies

As noted earlier, this study is not the first to estimate the economic benefits of public infrastructure spending in Ontario. This section compares the results from this analysis with those published by the Broadbent Institute (2015), two reports by the Conference Board of Canada (2010, 2013), the Canadian Centre for Economic Analysis (2015) and, for an international perspective, one by the US Congressional Budget Office (2016).

The C_4SE's study for the Broadbent Institute (2015) estimated the construction phase (short-term) GDP multiplier for Ontario to be 1.15 with estimates for the other provinces ranging from 0.54 to 1.77. The Conference Board of Canada (2010, 2013) estimated the short-term GDP multiplier to be 1.11 in a 2010 study and 1.14 in a 2013 study. The current estimate of 0.91 is within the range of possible multipliers for the range of assets included in the Province's infrastructure spending plan.

There are three basic reasons for the differences in estimated short-run multipliers: differences in model history and forecast data (i.e. the economic environment), differences in model design, and differences in program design including differences in asset mix, program duration and total spending. All three play a role in the differences between the current results and those from the Broadbent Institute and the Conference Board of Canada studies.

Table 5

Comparison of Current Results with Other Studies			
Broadbent Institute (short-run multiplier)			
	C4SE	**BI (2015)**	***Ratio***
Ontario GDP	0.91	1.15	*1.3*
Ontario Employment (jobs per $million)	4.7	7.6	*1.6*
Ontario Non-residential Investment	1.14	1.20	*1.1*
Fed/Prov Tax Revenue	0.27	0.40	*1.5*
Conference Board of Canada (short-run multiplier)			
	C4SE	**CBOC (2010)**	**CBOC (2013)**
Ontario GDP	0.91	1.11	1.14
Ontario Employment (jobs per $million)	4.7	12.4	13.5
Ontario Business Investment	0.14		0.37
Congressional Budget Office (short-run multiplier)			
	C4SE	**CBO #3 (2016)**	**CBO #4 (2016)**
GDP	0.91	0.45	0.03
Federal Government Revenues		0.04	-0.01
Thirty year (2015-2045) impacts of $1 billion of public infrastructure spending in Ontario			
	C4SE	**CANCEA (2015)**	***Ratio***
Ontario GDP	7.4	16.3	*2.2*
Ontario Employment (job-years per $million)	22.6	85.0	*3.8*
Ontario Productivity	0.33	0.19	*0.6*
Ontario Business Investment	1.2	4.4	*3.5*
Ontario Tax Revenues	0.6	1.7	*2.9*
Federal Tax Revenues	0.5	1.6	*3.3*

The Conference Board of Canada's public capital spending employment multiplier, expressed in terms of jobs per $1 million (2015 reference year dollars) of spending, was 12.4 in the 2010 study and 13.5 in the 2013 study. The C_4SE's Broadbent Institute study estimated the employment multiplier for Ontario to be 7.6 with the multiplier for other provinces between 3.6 and 13.6. The current study's result of 4.7 is low relative to the Conference Board and reflects differences in the response of the two models' labour markets to new infrastructure spending. The importance of model structure is also reflected in the Province's estimate in Budget 2016 that planned infrastructure investments would support over 110,000 jobs, on average, each year versus the 57,000 jobs estimated in this study. The Province's estimate was derived from a static input-output model in which employment is directly linked to output with no gains in productivity possible, whereas the C_4SE's models allow for changes in labour supply, wages rates and productivity. The increase in economic activity from Plan spending increases wages and prices in the C_4SE model which raises unit labour costs and hurts Ontario's trade competitiveness during the Plan Spending period.

The influence of model design and simulation assumptions on estimated impacts should not be underestimated. The US Congressional Budget Office estimated the impact of various national public

infrastructure spending programs. Their analysis of deficit-financed infrastructure spending programs yielded short-term GDP impact multipliers of between 0.03 and 0.45 compared to 0.91 in the current study. In their model, public spending 'crowds out' a significant portion of private spending in the economy.

The long-term impact of Ontario's current infrastructure plan was also estimated by the Canadian Centre for Economic Analysis (CANCEA 2015) using an agent-based modeling system. They reported a $16.3 billion dollar increase in provincial GDP for each billion dollars of infrastructure spending over 30 years and remarked that this outcome results in 'sticker shock' when compared with other models. The full benefits case scenario in this report yields an increase of up to $7.4 billion dollars of provincial GDP per billion dollars of infrastructure spending over a similar period.

CANCEA's model led to an increase in employment of 85,000 person-years per billion dollars of spending compared to 23,000 from the full benefits case scenario over 30 years in the current study. CANCEA's increase in GDP and employment encourages business investment to rise $4.4 billion and Ontario's government revenues to grow $1.7 billion over 30 years compared to $1.2 billion and $0.6 billion respectively from the full benefits case scenario.

Unfortunately, the range of economic impact results from public infrastructure spending remains relatively large and open to debate. The C_4SE believes that the current results are reasonable and plausible, and while they may be conservative they are based on a comprehensive analysis of the specific spending included in the Provincial infrastructure spending plan including information that was not available to other researchers.

Other Benefits from Public Infrastructure

The analysis presented in this report represents only part of the benefits to the economy and society at large thought to flow from public infrastructure. In particular, we have focused on the competitiveness benefits to private industry from basic public infrastructure. These benefits were generated from Plan Spending on engineering construction and transit-related spending on machinery and equipment. This, however, excludes any benefits arising from: (i) externalities[22] from this spending affecting other sectors; or (ii) externalities from public spending on non-residential buildings, machinery and equipment and intellectual property. While economic theory suggests that these other benefits exist, there is no research available to help quantify their contribution to the economy.

Engineering construction and spending on transit-related machinery and equipment will confer benefits to other sectors of the economy. For example, households will benefit from better transportation networks. While there is extensive research examining links between transportation, the value of time and the costs of congestion, pollution and greenhouse gas emissions, there are no reliable estimates of the benefit of public spending. Transportation networks are also believed to boost productivity by promoting the agglomeration or clustering of firms and skilled labour in an urban area. Better transportation networks may also, however, encourage urban sprawl, leading to higher air pollution and greenhouse gas emissions. The analysis in this paper captures some of these agglomeration benefits through the cost-savings benefits to industry arising from enhanced transportation networks.

The benefits from a more educated labour force, better health care outcomes, more effective law enforcement and fire protection are just some of the outcomes that can arise from public spending on non-residential buildings and other assets to support the delivery of education, health and other public services. These benefits could raise the supply of labour by allowing more people to stay at work or to join the labour force which could further enhance productivity. There are, however, no reliable estimates linking public infrastructure spending to these benefits.

There are also benefits that arise from public housing, public community centres, libraries, parks and public spaces that enhance our quality of life. Quantifying these benefits, however, remains elusive for an economic impact analysis.

[22] In economics, an externality is a cost or benefit borne by one party that arises as a result of the actions of another party.

Summary and Observations

Ontario's 10-year public infrastructure spending plan can lay the foundation for future growth and prosperity in this province. Productive public infrastructure reduces costs for private businesses; providing a compelling case for public funding of this capital. The C_4SE believes that the full benefits case results, based on the cost elasticity estimates from Harchaoui and Tarkhani (2003), are credible and represent the benefits that should accrue from spending on public infrastructure. But there is a risk that a large infrastructure program could yield lower benefits, so that the half benefits case provides a prudent lower-bound to the analysis.

The short-run economic benefits include a GDP multiplier of 0.91, 4.7 jobs generated per million dollars spent, and $0.27 of government revenue recovered per dollar spent. Over the long-run, the return on investment to GDP from spending on public capital, assuming a 2.5% discount rate, lies between 3.0 and 6.0 for the half and full benefits case scenarios. This means that every dollar invested in infrastructure results in an increase of up to $6 in real GDP over the long-term. This result can justify the Province's 10-year public infrastructure spending plan and still remains high when higher discount rates are assumed. Total government revenue recovered is between $0.45 and $0.88 and provincial government revenue is between $0.25 and $0.47 for the half and full benefits case scenarios helping to mitigate the long-run fiscal impact.

Some critics may note that the long-run increase in employment of between 9 and 18 jobs generated per million dollars spent on public capital is low and that the money would be better spent on other priorities — or not spent at all. This result arises, in part, from the design of the C_4SE's provincial economic modeling system where changes in wage rates and migration force the unemployment rate to adjust towards its natural rate over time.[23] While employment gains may be limited, businesses are more productive and competitive and workers earn higher real wages: up between 2.4% and 5.1% in the Post-plan period on average in the half and full benefits case scenarios relative to the baseline.

The increase in public capital can also help achieve something else that has eluded policy makers in Canada over the last few years: gains in private sector investment spending. A public infrastructure program boosts private investment in both the near and long-term and can, therefore, play an important role in contributing to an investment-led economic expansion.

In summary, the benefits of a public infrastructure spending program include:

- Higher private sector investment,
- A more productive economy, and
- A higher standard of living.

[23] The natural rate of unemployment is the rate of unemployment that would exist without changes in the rate due to the economic cycle. It includes both structural (unemployment caused by forces other than the business cycle) and frictional (unemployment to facilitate job hunting) unemployment. The natural rate was not adjusted in this analysis to reflect potential benefits from public infrastructure spending because of a lack of research to help quantify an appropriate reduction. It should be noted, however, that the labour force participation rate rose in both the shock scenarios, relative to the baseline, as people were encouraged to work by higher real wage rates.

Although this study reports that significant economic benefits can be realized from the Province's public infrastructure plan, spending on these assets is also required to achieve other social objectives that have not been captured or quantified in this analysis. These benefits include those to households from lower transportation congestion costs, improved business networking opportunities, reductions in pollution and greenhouse gases, and societal gains from education, health care and other public assets.

In closing, this study also provides a cautionary tale for policy analysts. The costs of neglecting our public infrastructure are not zero. As noted by Infrastructure Canada (2011), allowing our public infrastructure to continue to decay imposes costs of at least equal but opposite consequence to the benefits estimated in this study. The competitiveness of private businesses in Ontario are tied to the quality of our public assets, especially given the shortfall of infrastructure investment in previous decades. Therefore, a significant and sustained public infrastructure spending initiative is required if households and businesses are to continue to enjoy a high standard of living.

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Appendix A: Contribution of Public Capital at the Industry Level

The following table can be found in Harchaoui and Tarkhani's (2003) paper (Table 5, p.17) and provides a summary of their empirical results. The industry cost elasticities, η_{CG}, were derived from national data for the period 1960-2000 and indicate the percentage change in the total private cost of producing a given level of output that is associated with a 1% change in the value of the public capital services and were used to adjust industry costs in the C_4SE's provincial economic modelling system. The impact on costs is largest for transportation and the wholesale and retail trade sectors. The weighted average aggregate impact on business costs is to lower them by 0.06% for every 1% increase in public capital.

Table 6

Translog Cost Function Elasticities				
	η_{CG}	$1/\eta$	$1/\eta^*$	η_{YG}
Agricultural and related services	-0.047	1.071	1.224	0.052
Fishing and trapping	-0.001	0.981	1.024	0.001
Logging and forestry	-0.014	1.012	1.091	0.014
Mining	-0.025	1.053	1.154	0.026
Crude petroleum and natural gas	-0.037	1.091	1.193	0.041
Quarry and sand pit	-0.010	0.912	1.012	0.009
Services incidental to mineral extraction	-0.012	0.946	1.029	0.011
Food	-0.037	1.026	1.141	0.038
Beverages	-0.035	1.044	1.159	0.037
Tobacco products industry	-0.019	0.984	1.043	0.019
Rubber products	-0.030	1.037	1.067	0.031
Plastic products	-0.017	1.047	1.093	0.018
Leather and allied products	-0.011	1.022	1.034	0.011
Primary textiles	-0.020	1.022	1.101	0.021
Textile products	-0.016	1.054	1.146	0.017
Clothing	-0.021	1.061	1.087	0.022
Wood	-0.031	1.034	1.053	0.032
Furniture and fixtures	-0.013	1.023	1.064	0.013
Paper and allied products	-0.034	1.067	1.125	0.036
Printing, publishing and allied products	-0.030	1.065	1.140	0.032
Primary metals	-0.052	1.047	1.157	0.055
Fabricated metal products	-0.049	1.075	1.171	0.053
Machinery ind. (except electrical mach.)	-0.053	1.125	1.234	0.060
Transportation equipment	-0.057	1.097	1.177	0.063
Electrical and electronic products	-0.003	1.146	1.241	0.003
Non-metallic mineral products	-0.022	1.033	1.097	0.023
Refined petroleum and coal products	-0.042	1.097	1.153	0.046
Chemical and chemical products	-0.035	1.058	1.197	0.037
Other manufacturing	-0.002	1.012	1.074	0.002
Construction	-0.070	1.034	1.223	0.072
Transportation	-0.093	1.046	1.279	0.097
Pipeline transport	-0.052	1.012	1.189	0.023
Storage and warehousing	-0.015	1.022	1.086	0.015
Communication	-0.069	1.097	1.124	0.075
Other utility	-0.061	1.012	1.087	0.062
Wholesale trade	-0.118	1.055	1.191	0.125
Retail trade	-0.121	1.063	1.221	0.129
Business Sector	**-0.062**	**1.058**	**1.176**	**0.066**

Source: Harchaoui and Tarkhani, Table 5, p. 17

Note: η_{CG} is the private cost elasticity with respect to private capital; $1/\eta$ is the internal return to scale, or the effect on output of a 1% increase in all inputs (private capital, labour and materials) except public capital; $1/\eta^*$ is the overall return to scale, or the effect on output of a 1% increase in all inputs including public capital; η_{YG} is the marginal productivity of public capital, or the effect on output of a 1% increase in public capital holding other inputs constant.

Appendix B: C_4SE Provincial Economic Modeling System

The C_4SE's Provincial Modeling System is a dynamic, multi-sector, regional economic model of the country. It includes a bottom-up set of macroeconomic models for the provinces, the territories and the rest of the world with a national model that links economic activity in one region with activity in the other regions through trade. The provincial models include detailed income and expenditure categories and demographic and labour market information. The purpose of the modeling system is to produce medium- to long-term projections of the provincial economies and conduct simulation studies that require industry and demographic detail.

The multi-sector model, which incorporates the purchasing patterns from the current input-output tables, captures the impact on the supply chain in terms of both output and employment. While this is also a feature of static input-output models, the C4SE's Provincial Modeling System also captures the impact on supplier's investment decisions that occur as a result of the change in economic activity.

The model produces impacts on employment, labour income, value added output, productivity, investment and exports for at least fourteen industry sectors (see list below). It also produces the impacts on government revenue by level of government and source of revenue. The dynamic nature of the model, however, makes it more challenging to develop a single summary measure that provides a "rule-of-thumb" result. The need for such a measure is satisfied by generating an average impact over several years of the simulation or, when appropriate, a Return on Investment statistic.

C_4SE Model – Industry Sectors

Agriculture	Finance, Insurance & Real Estate
Other Primary (detail varies by province)	Professional, Scientific & Management Services
Manufacturing (detail varies by province)	Accommodation & Food
Construction	Health Services
Utilities	Other Services
Transportation & Warehousing	Education Services
Wholesale & Retail Trade	Government Services

The model incorporates policy responses to economic developments. In terms of monetary policy, the Bank of Canada adjusts interest rates using a Taylor Rule reaction function that responds to inflation relative to its target rate and the unemployment rate relative to the natural rate of unemployment. The exchange rate reacts to Canada-US interest rate differentials and changes in the purchasing power parity value of the dollar. In terms of fiscal policy, government spending is, for many categories, a function of population, while government revenue reacts to changes in the tax base.

The following sections provide the reader with more information on the structure of the individual provincial models and the national model that unites the provincial and territorial models.

Provincial Models

The provincial and territorial models are very similar in structure – the parameters in each model differ to reflect differences in the economic experience of each region.

The provincial models are similar in nature to a general equilibrium model, but full product and factor substitution is not implemented. At present, substitution is restricted to the energy products and value-added. For purposes of manageability there is only one wage rate and one set of cost of capital measures – construction and equipment – in the model. Changes in these measures of labour and capital costs cause labour and capital intensities to change across all sectors of the economy.

The model's economy is organized into four broad sectors. Firms employ capital and labour to produce a profit-maximizing output under a Cobb-Douglas constant-returns-to-scale technology. Households consume the domestic and foreign products and supply labour under the assumption of utility maximization. Governments purchase the domestic and foreign products and produce output. Foreigners purchase the domestic product and supply the foreign product.

There are two main markets in the model. These markets correspond to the domestic and foreign products and the labour market. Each of these markets is concerned with the determination of demands, supplies, and prices. Like most sub-national models, the Ontario model assumes that most prices are set in national markets. The presence of the national model in the system means that interest rates, exchange rates and the price of some goods and services are affected by changes in economic activity in Ontario and the rest of the country.

In sub-national economies, the movement of labour is a key factor in the adjustment of the local economy to changes in economic conditions. The C_4SE's model allows net migration – and therefore the total population – to adjust over time to reflect changes in economic conditions. If the economy and employment is growing, then the demand for labour rises and net migration rises. This feature is an important consideration when examining economic impacts over one or more decades.

National Model

The design of the national model is what makes the C_4SE's system unique. The national block adds up the economic activity across the country and uses this information to help determine prices, interest rates, exchange rates and the rest-of-country external demand for goods and services – all factors that are exogenous to the other provincial modelling systems.

To see why this is important, consider an increase in one province's economy. This raises that province's demand for imports. In this system each of the other provinces sees an increase in demand for their exports to that province which, in turn, raises their own economies. The increase in economic activity will put upward pressure prices, interest rates and the exchange rate. The entire national economy, therefore, adjusts over time to the initial shock.

Full Benefits Case Scenario Impacts

Table 7

Ontario Government 10-year Plan Spending Impacts: Full Benefits Case Scenario	Average annual difference from baseline		Average annual percent difference from baseline	
	2016-2025	2026-2050	2016-2025	2026-2050
Real Expenditure (millions 2015$)				
Gross Domestic Product	12,323	57,533	1.5%	5.3%
Household Current Spending	9,400	40,063	2.0%	5.9%
Government Current Spending	508	1,963	0.3%	1.0%
Total non-residential Investment	14,716	12,103	18.6%	10.0%
Exports	-858	21,862	-0.2%	4.1%
Imports	11,303	17,202	2.9%	3.4%
Demographics, Labour & Housing				
Population (000s)	52.0	182.4	0.4%	1.1%
Net Migration (000s)	1.8	6.8	1.7%	7.2%
Labour Force (000s)	55.4	140.6	0.7%	1.7%
Participation Rate (%)	0.2	0.4		
Employment (000s)	61.2	150.5	0.9%	1.9%
Unemployment Rate (%)	-0.1	-0.2		
Housing Starts (000s)	1.2	3.2	1.5%	7.0%
Economic Performance Measures				
GDP per capita (2015 $s)	649	2,692	1.2%	4.1%
Disposable Income per capita (2015 $s)	523	1,855	1.7%	4.7%
Consumption per capita (2015 $s)	527	1,906	1.6%	4.6%
GDP per hour worked (2015 $s)	0.4	2.5	0.6%	3.3%
Wage & Price Impacts				
Gross Domestic Product			2.0%	-5.1%
Consumer Price Index			0.6%	-5.3%
Avg. Annual Real Labour Income (2015 $s)	1,118	3,737	1.8%	5.2%
Unit Labour Costs			1.8%	-3.6%
Federal Gov't (in Ontario)				
Revenue (millions 2015$)	1,679	3,097	1.5%	2.3%
Current Expenditure (millions 2015$)	-43	-1,504	0.0%	-1.1%
Fiscal Balance (millions 2015$)	1,704	4,644		
Ontario Government				
Revenue (millions 2015$)	1,682	4,043	1.4%	2.4%
Current Expenditure (millions 2015$)	1,805	4,909	1.4%	3.1%
Fiscal Balance (millions 2015$)	-9,108	-146		
Cumulative Fiscal Balance (millions 2015$)	49,387	84,562	16.1%	35.8%
Financial Markets				
3-Month T-Bill Rate (basis points)	7.4	4.3		
Exchange Rate (US cents)	0.5	-0.1	0.6%	-0.1%

Half Benefits Case Scenario Impacts

Table 8

Ontario Government 10-year Plan Spending Impacts: Half Benefits Case Scenario	Average annual difference from baseline		Average annual percent difference from baseline	
	2016-2025	2026-2050	2016-2025	2026-2050
Real Expenditure (millions 2015$)				
Gross Domestic Product	10,877	27,078	1.3%	2.5%
Household Current Spending	8,739	19,047	1.8%	2.8%
Government Current Spending	503	910	0.3%	0.5%
Total non-residential Investment	14,317	7,029	18.1%	5.8%
Exports	-1,694	9,574	-0.4%	1.8%
Imports	10,905	9,125	2.8%	1.8%
Demographics, Labour & Housing				
Population	51.3	84.2	0.4%	0.5%
Net Migration	1.5	3.1	1.4%	3.3%
Labour Force	54.3	62.0	0.7%	0.7%
Participation Rate	0.2	0.1		
Employment	59.0	66.7	0.8%	0.8%
Unemployment Rate	-0.1	-0.1		
Housing Starts	1.2	1.4	1.5%	3.0%
Economic Performance Measures				
GDP per capita (2015 $s)	556	1,273	1.0%	1.9%
Disposable Income per capita (2015 $s)	473	890	1.5%	2.3%
Consumption per capita (2015 $s)	485	912	1.5%	2.2%
GDP per hour worked (2015 $s)	0.3	1.2	0.5%	1.6%
Wage & Price Impacts				
Gross Domestic Product			2.3%	-2.2%
Consumer Price Index			1.0%	-2.4%
Avg. Annual Real Labour Income (2015 $s)	1,019	1,788	1.7%	2.5%
Unit Labour Costs			2.2%	-1.6%
Federal Gov't (in Ontario)				
Revenue (millions 2015$)	1,638	1,072	1.4%	0.8%
Current Expenditure (millions 2015$)	20	-899	0.0%	-0.7%
Fiscal Balance (millions 2015$)	1,598	2,015		
Ontario Government				
Revenue (millions 2015$)	1,696	1,736	1.4%	1.0%
Current Expenditure (millions 2015$)	1,809	4,996	1.4%	3.1%
Fiscal Balance (millions 2015$)	-9,098	-2,515		
Cumulative Fiscal Balance (millions 2015$)	48,738	99,394	15.9%	42.1%
Financial Markets				
3-Month T-Bill Rate (basis points)	9.5	0.5		
Exchange Rate (US cents)	0.5	0.1	0.6%	0.1%