The Economic Benefits of Public Infrastructure Spending in Canada

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BY The Centre for Spatial Economics* | September 2015

*The C4SE 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 clients. The Broadbent Institute commissioned C4SE to conduct independent economic modeling on the economic benefits of public infrastructure investment. For more information, please see www.c4se.com.

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ABOUT THIS STUDY

This report was prepared for the Broadbent Institute by the Centre for Spatial Economics (C_4SE). The Broadbent Institute is an independent, non-partisan organization championing progressive change through the promotion of democracy, equality, and sustainability and the training of a new generation of leaders. For more information, please see www.broadbentinstitute.ca.

This paper estimates the economic benefits of a national five-year, $50-billion public infrastructure spending program using the C_4SE's provincial economic modelling system. Results are presented in terms of impacts upon gross domestic product (GDP), employment, and government finances over time, by sector, and by province. Spending multipliers and return on investment statistics are generated to provide summary measures of the results and provide a compelling case for funding a public infrastructure program 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 Canada.

The report was conducted by economist Robin Somerville, Director at the 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 see www.c4se.com.

EXECUTIVE SUMMARY

This report provides estimates of the economic benefits of a five-year, $50-billion public infrastructure spending program in Canada funded equally by the federal and provincial governments. Public infrastructure is defined as the engineering construction component of all levels—federal, provincial and territorial, and local—of the public administration sector's capital stock, and includes primarily transportation systems, such as subways and highways, water supply, and wastewater treatment facilities. The benefits of a national public infrastructure program arise from the direct program spending, but then extend beyond this direct impact with public capital promoting long-term economic growth and productivity. Federal and provincial funding for the program is assumed to come from either existing budget surpluses or from deficit financing. Tax rates are left at baseline scenario levels so as to prevent mixing the results of the spending initiative with the impact of selected tax increases.

The report does not advocate for one financing option over others, but models one option based on fiscal projections and economic outlooks as of January 2015 (see Appendix B).

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

- In the short term, GDP rises $1.43 per dollar of spending, 9.4 jobs are generated per million dollars spent, and $0.44 of each dollar spent by government is recovered in additional tax revenue.
- Over the long term, the discounted present value of GDP generated per dollar of public infrastructure spending (return on investment) lies between $2.46 and $3.83.
- Private-sector investment rises by as much as $0.34 per dollar spent in the short term, and by up to $1.00 per dollar spent in the long run.
- Businesses are more productive and competitive in international markets.
- Real wages rise, providing a higher standard of living for Canadians.

And these benefits are realized without significant long-term fiscal consequences to federal or provincial governments. The change in the long-term average annual deficit-to-GDP ratio lies between a rise of 0.04 per cent and a decline of 0.02 per cent for the federal government, and between a rise of 0.08 per cent

and a fall of 0.04 per cent for provincial governments. The overall long-term impact on both federal and provincial governments is therefore likely to be very small, and may even be positive.

Table 1

Public Infrastructure Spending: Summary of Results

			Long-run Return on Investment (3% discount rate)		
		Short-run Total Impact Multipier	Zero Benefits Case	Half Benefits Case	Full Benefits Case
GDP	PER $ SPENDING	1.43	1.10	2.46	3.83
JOBS	PER $ MILLION SPENDING	9.4	3.0	5.0	7.1
FEDERAL TAX REVENUE	PER $ SPENDING	0.43	0.10	0.16	0.21
PROVINCIAL TAX REVENUE	PER $ SPENDING	0.45	0.04	0.30	0.51

On a sectoral basis, half of the short-term gains in GDP accrue to the construction sector, with the other half distributed across other private-sector industries. In the long run, the construction sector still makes the largest gains, but the overwhelming majority of gains accrue to other private-sector industries. Gains to the broader public sector are minimal in both the short and long run.

As may be expected, the benefits from a national public infrastructure spending program are felt across the country, although the benefits are larger in some provinces than others: In the short run, Quebec and British Columbia experience the strongest gains relative to the baseline, while Saskatchewan and Newfoundland and Labrador experience the weakest. Factors influencing short-term benefits on a provincial basis include differences in import propensities, where provinces that need to import more goods and services rather than producing them within the province experience weaker benefits. On a more technical level, differences in GDP shares relative to the population shares used to allocate program spending across the country will also affect the outcome, with GDP shares higher than the population shares leading to smaller benefits in terms of additional GDP relative to the baseline[1]. Over the long run, the impact on average annual GDP depends considerably more on the size of the benefits to private industry from public capital than it does on the province. The difference in impacts across provinces is significantly lower in the long run than it is over the five-year construction phase.

1 Resource-rich provinces like Alberta and Saskatchewan have higher shares of national GDP than they do national population.

Study Methodology

The analysis consists of four scenarios and was conducted using the C_4SE's provincial economic modelling system, which is a multi-region, multi-sector, dynamic stochastic general equilibrium model of Canada and its provinces. The ***baseline scenario*** does not include any additional public infrastructure spending, and is the benchmark against which each of the other scenarios is compared. The other three scenarios reflect changes in economic activity arising from the public infrastructure spending program. The first of these scenarios is the ***zero benefits case,*** which assumes that public infrastructure provides no benefit to private business. The second and third scenarios are the ***half*** and ***full benefits cases,*** which assume respectively that the new public infrastructure provides either half or all the benefits to private business estimated by the research of Harchaoui and Tarkhani (2003). The zero benefits case is not considered a likely outcome, but is included to allow readers to assess the impact of reduced private business costs from new public infrastructure by comparing it against the half and full benefits cases. Federal and provincial funding for the program is assumed to come from either existing budget surpluses or from deficit financing. Tax rates are left at baseline scenario levels so as to prevent mixing the results of the spending initiative with the impact of selected tax increases.

Productive public infrastructure reduces costs for private businesses—boosting GDP by up to $3.83 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 elasticity estimates from Harchaoui and Tarkhani, are credible and represent the benefits that should accrue from spending on public infrastructure. Although the five-year, $50 billion program size is arbitrary, it is evident that a program of this scale is required to begin to address the estimated $171.8 billion cost of replacing the municipal assets rated fair, poor, or very poor condition across the country. Because there is always a risk that such a large infrastructure program could be administered inefficiently, leading the economy to realize fewer benefits (perhaps as low as the half benefits case results), it is imperative to structure such programs so that they are designed and managed well.

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.

While a five-year, $50-billion program does represent a major spending commitment for Canada's federal and provincial governments, public infrastructure spending has been curtailed for decades as governments of all levels have restrained spending in order to avoid increases in tax rates or to provide tax cuts. In the absence of surpluses, taxes or deficits will need to rise, at least in the short term, but, because of the expected benefits to private business from the public capital, they need not become a significant long-term burden.

In closing, this study also provides a cautionary tale for policy analysts. The costs of neglecting our public infrastructure are not zero: Allowing our public infrastructure to continue to decay imposes costs at least equal but opposite to the benefits estimated in this study. The competitiveness of private businesses in Canada is tied to the quality of our public assets, so a significant and sustained public infrastructure spending initiative is required if households and businesses are to continue to enjoy the high standard of living provided by our public infrastructure.

INTRODUCTION

Media reports of crumbling and even dangerous public infrastructure have become commonplace. Large sinkholes now routinely disrupt life in Canada's largest cities. Many critical bridges and highways need immediate attention. And traffic gridlock in urban centres underscores the need for major investment to improve and expand public transit. While everyday experience suggests that Canada's public infrastructure is in need of renewal, common observation is also confirmed by research.

Lemire and Gaudreault (2006) estimated that in 2003, Canada's road and highway network had over 50 per cent of its useful life behind it, while federal and provincial bridges had passed the halfway mark of their useful lives. Municipal bridges fared a little better with 41 per cent of their useful lives behind them. More recently, Guy Félio (2012) prepared a report for the Federation of Canadian Municipalities that estimated the replacement cost of municipal infrastructure assets that were rated between "fair" and "very poor" to be $171.8 billion in 2010. Federal and provincial governments have included spending initiatives in recent budgets, but, after 25 years of underinvestment, the spending required to correct the issue will require significantly more resources and sustained commitment by all levels of government.

This report provides estimates of the economic benefits of public infrastructure spending in Canada. Public infrastructure is defined as the engineering construction component of all levels—federal, provincial and territorial, and local—of the public administration sector's capital stock, and includes primarily transportation systems, such as subways and highways, water supply, and wastewater treatment facilities.

The benefits of a national public infrastructure program arise from the direct program spending and accrue principally to the construction sector. However, the benefits from public infrastructure extend beyond this direct impact, with public capital promoting economic growth and productivity. A highway, for example, allows trucks to transport goods in less time than if they used slower, local roads. This reduces shipping costs, helping private companies produce their products at a lower cost.

A study prepared for Transport Canada (2006) estimates that the total annual cost of congestion in terms of lost time and fuel consumption for Canada's nine major urban areas lies between $2.3 billion and $3.7 billion (measured in 2002

dollars).[2] It is important to note, however, that the condition of the highway is just as important as its existence. According to Infrastructure Canada (2011), "Inadequate infrastructure can deter foreign investors. Research shows that inadequate public infrastructure tends to drive away foreign investment more so than quality infrastructure attracts private investment. This, in turn, suggests that public infrastructure is taken 'as a given'—something that must be present."

The need for public infrastructure and its importance to economic performance is intuitively clear. Canada's aging infrastructure could be an important contributing factor to our lacklustre productivity gains. The challenge, from a research perspective, is how to link public infrastructure spending to economic performance so that we can estimate the benefits to society from that spending.

Economic Theory: Linking Infrastructure and Economic Performance

There are many critics of public spending that argue that it provides no benefits to society. Media reports of overpriced doorknobs or gazebos make it easy to think of examples of public infrastructure projects that provide little or no benefit to business or to the public. These examples, however, are the exceptions that prove the rule, as economic studies over the last 25 years have consistently found a positive link between public infrastructure and productivity.

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 GDP is not well understood. 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 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

2 These costs rise to between $3.0 billion and $4.9 billion a year when valued in terms of current prices, although actual costs are likely to be significantly higher than this when factoring in the higher cost of petroleum since the study was conducted.

capital in Canada. Using a production function and Canadian aggregate data from 1946 to 1991, Wylie finds that government capital has a positive elasticity. He 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. Critics of these econometric studies have said that they fail to account for non-stationarity in the data, 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 U.S. industries, and obtained smaller, more credible estimates of the benefits from public capital. Harchaoui and Tarkhani (2003) applied a similar approach using Canadian data.

Finally, Baldwin, Gu, and Macdonald (2010) took an alternative non-parametric approach to productivity analysis 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. Critics of earlier studies that adopted this approach say that it is unclear how large of an effect public capital has on productivity growth or whether the impact varies over time. More recent research by Baldwin, Gu, and Macdonald, however, specifically incorporates public capital using the benefits estimated by Harchaoui and Tarkhani and others.

Harchaoui and Tarkhani estimated the effects of public capital on business-sector production costs, level of output, and demand for labour, capital, and intermediate goods using Canadian data for 37 industries for the 1961–2000 period using a translog cost function. They found that an increase in public capital has an initial direct impact on productivity: 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 Harchaoui and Tarkhani's results), with the largest benefits accruing to the transportation, wholesale, retail, and other utility

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.

sectors. The economic impact of public capital on the various industries does not stop with the direct productivity effect. Cost reductions permit products to be sold at lower prices, and lower prices can be expected to lead to higher sales and output growth. Harchaoui and Tarkhani 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. When industry production levels increase due to the "output effect" of public capital, the demand for labour and intermediate inputs is reduced, while the demand for private capital increases in all industries. 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 implies that public capital is a complement to private capital.

This paper uses the findings from Harchaoui and Tarkhani to estimate the economic benefits of a national five-year, $50-billion public infrastructure spending program using the C_4SE's provincial economic modelling system. The size of the program chosen for this study is arbitrary, and is meant to be illustrative of the types of benefits that could accrue from a major program of this nature. The results in this paper can, within limits, generally be scaled to larger or smaller spending initiatives.[4] The next section discusses the study methodology and assumptions and is followed by the results. Results are presented in terms of impacts upon GDP, employment, and government finances over time, by sector, and by province. Spending multipliers and return on investment statistics are generated to provide summary measures of the results. The paper concludes with some observations based on the results.

4 A small program would need to be evaluated on the specifics of the project and the results could vary widely from the "average" project portfolio examined in this report, while a very large program would introduce distortions in markets for labour and materials that would not be captured by the model, which is predicated on the notion of marginal changes from current economic conditions.

METHODOLOGY AND ASSUMPTIONS

The benefits of a national public infrastructure program—which accrue principally to the construction sector—arise from the direct program spending and beyond, with public capital promoting economic growth and productivity.

Direct Construction Phase Assumptions and Impact

The five-year, $50-billion public infrastructure spending program starts in 2015 and is dedicated to public transit and other municipal infrastructure. The program is funded equally by the federal and provincial governments, with spending allocated across provinces based on their share of the national population in 2014 (see Table 2). Annual spending of $10 billion yields cumulative spending of $46.7 billion (expressed in 2014 dollar terms) over the five years, and directly supports an average of 42,150 construction-sector workers a year. These spending assumptions are entered into the C_4SE's provincial economic modelling system, raising local government engineering construction spending by province and funded by transfers from federal and provincial governments.

Federal and provincial funding for the program is assumed to come from either existing budget surpluses or from deficit financing. Tax rates are left at baseline scenario levels. This assumption is typical when conducting this type of policy analysis. Tax increases reduce economic activity—although the precise impact varies by the type of tax that is raised. Keeping tax rates unchanged prevents mixing the results of the spending initiative with the impact of selected tax increases.

Table 2

Public Infrastructure Program Assumptions

		Pubic Infrastructure Spending ($ Million, 2015–2019)			Direct Construction Sector employment
	% Population Share (2014)	Annual	Cumulative	Cumulative (2014 dollars)	
CANADA	100	10,000.0	50,000.0	46,677.3	42,148
BRITISH COLUMBIA	13.1	1,307.5	6,537.5	6,084.6	5,502
ALBERTA	11.6	1,163.6	5,818.2	5,462.3	4,807
SASKATCHEWAN	3.2	317.7	1,588.6	1,476.3	1,295
MANITOBA	3.6	361.9	1,809.7	1,691.5	1,509
ONTARIO	38.6	3,861.8	19,308.9	18,065.6	16,685
QUEBEC	23.2	2,319.2	11,595.8	10,782.4	9,525
NEW BRUNSWICK	2.1	212.8	1,064.2	996.3	890
NOVA SCOTIA	2.7	265.3	1,326.6	1,235.4	1,125
PRINCE EDWARD ISLAND	0.4	41.3	206.5	188.9	174
NEWFOUNDLAND & LABRADOR	1.5	148.8	743.9	693.9	636

Once built, it is assumed that this public infrastructure will be maintained and repaired. The implicit depreciation rate generated from Statistics Canada's data for public-sector engineering construction is nine per cent, indicating an average service life of 11 years. The estimated service life of public infrastructure varies from as little as 15 years for some roads up to 150 years for main sewers (Félio 2012, 11). This study assumes that the infrastructure projects built under this program will have an average service life of 25 years. Public-sector spending from 2020 on is permanently raised by $1.87 billion a year (measured in 2014 dollars). The cost of maintaining the capital will be higher if a shorter average service life is assumed, while a longer service life will lower the cost.

Benefits to Private Industry

The private industry cost elasticities estimated by Harchaoui and Tarkhani are used to reduce production costs by business sector in the C_4SE's provincial economic modelling system. A table showing the elasticities of costs with respect to public capital by business sector is reproduced in Appendix A. A $50-billion spending program raises the value of the stock of public infrastructure capital in Canada by just over 18 per cent by 2020. Production costs by industry are therefore eventually reduced by 18 times the estimated cost elasticity.

The changes in industry costs are introduced into the C_4SE's model after the first full year of infrastructure spending (in 2016), and reach their maximum by 2020. The benefits to industry in terms of reduced costs continue over the design life of the public capital. Maintaining the public infrastructure so that the net capital stock value is preserved therefore allows these benefits to persist throughout the simulation period. Another important assumption is that the use of public capital by one industry does not preclude or reduce the value of its use by any other industry.

A Scenario-Based Approach to Modelling Uncertainty

Many economists consider the private industry cost elasticities estimated by Harchaoui and Tarkhani to be plausible. Harchaoui and Tarkhani's work corrects the methodological concerns of earlier studies and produces elasticities that are significantly smaller than those from earlier empirical studies. There is still debate and uncertainty, however, over the precise level of benefit conferred to private industry from public capital.

Uncertainty is modelled through a set of scenarios. The first of these scenarios 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 are not meant to represent a likely outcome. They are, as will be seen, helpful in evaluating the benefits of lower industry costs from public capital upon the economy.

Two more plausible scenarios are provided to evaluate the benefits of lower industry costs: the half benefits case and the full benefits case. The half benefits case halves Harchaoui and Tarkhani's 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 dubious 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.

A final scenario, referred to as the baseline scenario, does not include any additional public infrastructure spending. This is the benchmark against which each of the other scenarios is compared. This scenario is summarized in Appendix B.

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 modelling system, which is a multi-region, multi-sector, dynamic stochastic general equilibrium model of Canada and its provinces. The model is described in more detail in Appendix B.

The analysis consists of the four scenarios described in the previous section: the baseline scenario, the zero benefits case, and the half and full benefits cases. Table 3 summarizes the economic benefits from these scenarios by comparing activity in the three public infrastructure spending scenarios against the baseline scenario.[5]

5 A set of tables describing the macroeconomic impacts across Canada in more detail is provided in Appendix C.

Table 3

Summary of Economic Impact of Public Infrastructure Spending on Canada's Economy

(2014 Dollars)	Difference from the Baseline		Percentage Difference from the Baseline	
	Average Annual 2015–19	Average Annual 2020–40	Average Annual 2015–19	Average Annual 2020–40
GDP	**$ MILLION**	**$ MILLION**	**%**	**%**
Zero Benefit to Private Business	13,327	1,263	0.6	0.0
Half Benefit to Private Business	14,169	7,586	0.7	0.3
Full Benefit to Private Business	15,013	13,903	0.7	0.5
EMPLOYMENT	**THOUSAND**	**THOUSAND**	**%**	**%**
Zero Benefit to Private Business	88	-12	0.5	-0.1
Half Benefit to Private Business	84	-1	0.5	0.0%
Full Benefit to Private Business	81	9	0.4	0.0
NON-RESIDENTIAL FIXED INVESTMENT SPENDING	**$ MILLION**	**$ MILLION**	**%**	**%**
Zero Benefit to Private Business	12,538	1,442	3.6	0.3
Half Benefit to Private Business	13,043	3,096	3.7	0.7
Full Benefit to Private Business	13,551	4,750	3.9	1.1

The total impacts for the zero benefits case in Table 3 include the direct increase in public infrastructure spending outlined in the previous section, plus the indirect impact on suppliers to the construction companies (of everything from office supplies to construction equipment), plus the induced impacts. Induced impacts include the impact on the economy from employees at the direct and indirect level as they spend their incomes—spending that in turn generates income for others, who re-spend it.

The provincial economic modelling system also considers changes in business investment spending arising from shifts in the economy, changes in wages, prices, and 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 larger than the direct increase in spending.

The impact on GDP, measured in millions of 2014 dollars, during the spending program (2015–19) is smallest for the zero benefits case at an annual average of $13.3 billion (or 0.6 per cent) higher than in the baseline scenario, compared to an annual average of $15.0 billion (or 0.7 per cent) higher in the full benefits case. This pattern also holds for non-residential fixed investment over this period. It is worth noting that the average annual increase in fixed non-residential investment exceeds public infrastructure program spending of $9.3 billion a year (expressed in 2014 dollars) by at least $3 billion in all three shock scenarios. As suggested by Harchaoui and Tarkhani, investment spending by private business responds positively to the increase in public capital, with the

size of this effect depending on the increase in productivity to private business from public infrastructure.

The impact on employment during this period follows a different pattern. The increase in average annual employment relative to the baseline is 88,000 in the zero benefits case but 81,000 in the full benefits case. These results also mirror those of Harchaoui and Tarkhani. Spending on public infrastructure raises employment, but the size of the increase diminishes as the productivity of public infrastructure to private business rises. This is because increases in public capital reduce the demand for labour and intermediate inputs.

After the infrastructure program ends, average annual GDP in the zero benefits case, measured in 2014 dollars, is just $1.3 billion a year higher than in the baseline scenario—less than the $1.9-billion increase in spending to maintain and repair the new public infrastructure. Reductions in business costs incorporated in the half and full benefits cases lead to increases in GDP relative to the baseline of between $7.6 and $13.9 billion a year.

Although the zero benefits case is not considered a likely outcome, the reader is encouraged to compare the outcome of the full and half benefits cases against it to assess the benefits to the economy that can be attributed to the increase in productivity to private business from public infrastructure. These benefits amount to an average of between $6.3 and $12.6 billion of additional GDP a year, with the full benefits case conferring twice the benefit of the half benefits case.

The long-term impact on non-residential investment spending follows the same pattern as GDP. The half benefits case raises average annual investment by $1.7 billion relative to the zero benefits case, while the full benefits case raises it by $3.4 billion. As seen in the short term, increases in public infrastructure spending encourage private business to increase investment spending.

Finally, the long-term impact on employment is very small for all three shock scenarios relative to the baseline. Comparing the half and full benefits cases to the zero benefits case yields an average annual increase in jobs of 11,000 and 21,000, respectively. In contrast to the short term, in the long run higher productivity levels lead to more jobs. This result is discussed in more detail later in this section.

Figures 1–3 provide a summary of the impacts on select key economic measures for each shock scenario relative to the baseline over the five-year construction phase and over the long run.

Figure 1

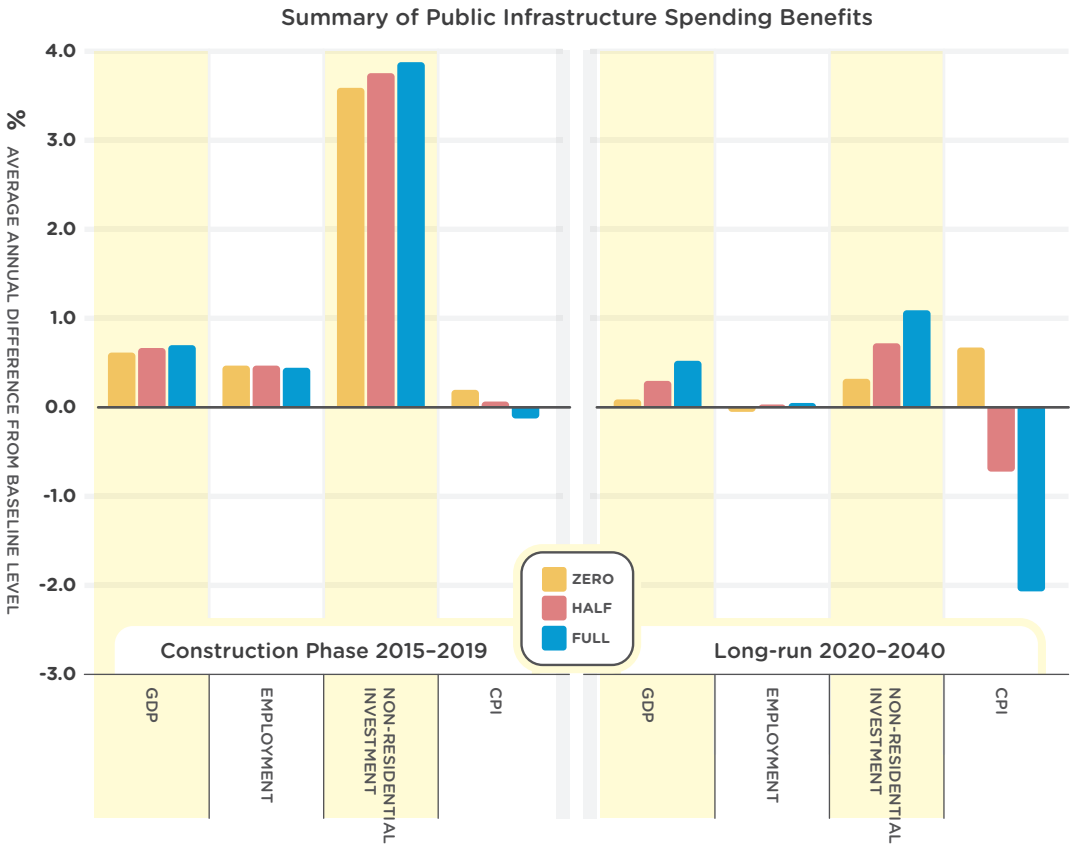


Figure 1 displays the data from Table 2, and includes the impact on the level of the consumer price index (CPI) relative to the baseline. In the five years of the construction phase, the CPI is driven slightly higher than the baseline in the zero benefits case, but lower industry costs from higher productivity feed through to the CPI in the half and full benefits cases. The difference in CPI impacts across shock scenarios becomes even more pronounced over the long run as the benefits from lower industry costs continue to reduce prices throughout the economy.

Figure 2

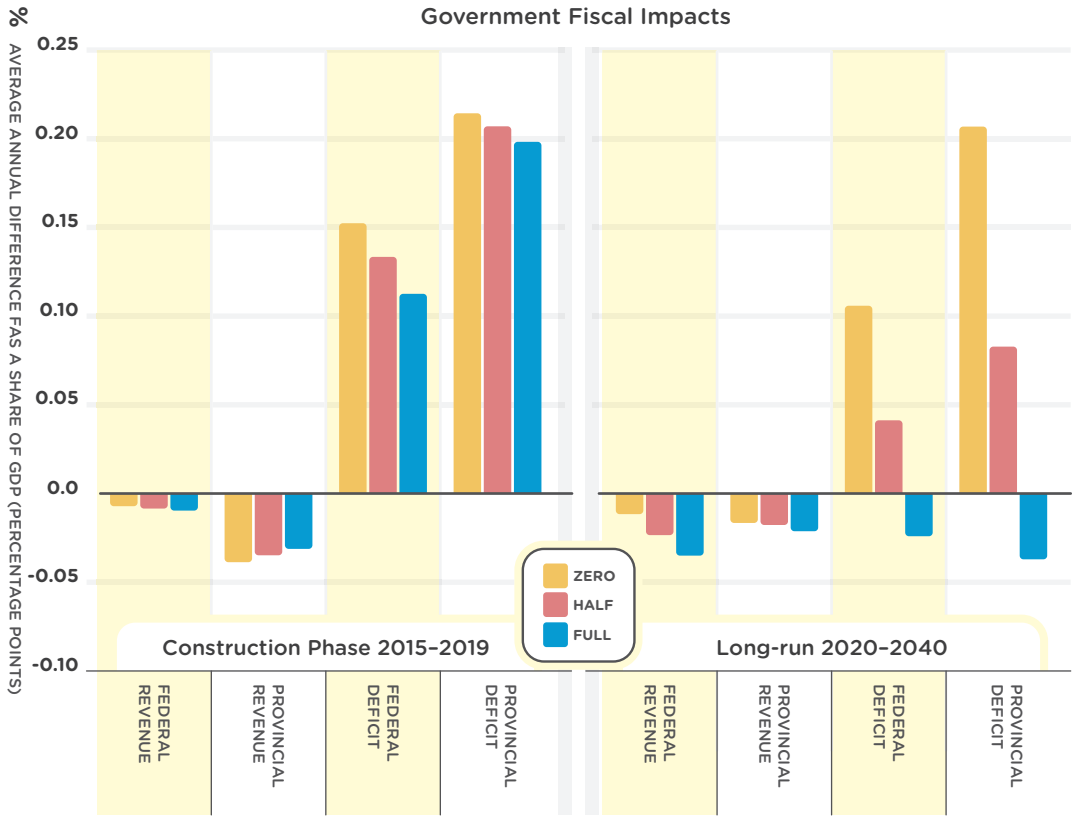
The impact on a set of prosperity and competitiveness measures is shown in Figure 2. The average annual percent increase, relative to the baseline, in real per capita disposable income is the same for all three shock scenarios during the five-year construction phase, but is higher for the full and half benefits cases in the long run. Average annual labour productivity (output per hour worked) is higher, relative to the baseline, for all three shock scenarios, but is stronger when industry costs are reduced through new public infrastructure—and this effect is enhanced over the long run.

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. Higher wages during the five-year construction phase push up unit labour costs in all three shock scenarios. The increase in unit labour costs, however, is higher for the zero benefits case, and this persists in the long run as wages and costs continue to rise. Reductions in industry costs

have a significant impact on unit labour costs over the long run due to lower wages[6] and increased productivity.

Shifts in competitiveness influence the trade balance. In the short term, however, the trade balance—expressed as the average annual difference from the baseline of the real trade balance as a share of real GDP—is more heavily influenced by the need to import materials to support the infrastructure spending program, and falls by about the same amount in all three shock scenarios. In the long run, the more competitive economy in the full benefits case leads to an improvement in the trade balance, whereas it remains depressed, relative to the baseline, in the zero benefits case.

Figure 3



6 It is important to note that real wages – wages after inflation – are higher in both the short term and long term for all three scenarios relative to the baseline. Increases in productivity lead to higher real wages and an improved standard of living.

The impact on government finances is summarized in Figure 3. The impact on government revenues is expressed as the change, relative to the baseline, of GDP. The impact on government deficits or surpluses are similarly expressed as a share of GDP.

During the five-year construction phase, average annual government revenues rise, but not as rapidly as nominal GDP, so their share declines.[7] The impact is stronger for the combined provincial governments than for the federal government because natural-resource revenues for provinces such as Alberta, Saskatchewan, and Newfoundland and Labrador are largely unchanged from their baseline levels, leaving these provinces with smaller increases in their overall revenues. Average annual government deficits, as a share of GDP, at both the federal and provincial level are higher relative to the baseline. This is hardly surprising as higher spending—as a share of GDP—collides with lower revenues as a share of GDP. Stronger economic growth in the full benefits case helps to partially reduce the increase in the deficit relative to the zero benefits case.

Over the long run, average annual government revenues as a share of GDP remain lower relative to the baseline for all three shock scenarios, with the impact slightly worse for the half and full benefits cases than the zero benefits case. The long-run impact on government deficits as a share of GDP is more interesting. The lack of long-run economic expansion in the zero benefits case means that higher debt-servicing costs, in conjunction with the cost of maintaining and repairing the new public infrastructure, leave both federal and provincial government deficits higher as a share of GDP relative to the baseline. The higher economic activity in the full benefits case, however, actually leads to a reduction in both federal and provincial deficits as a share of GDP relative to the baseline.

The next section examines the results on a year-by-year basis so as to provide the reader with a better understanding of the dynamic properties of the C_4SE's provincial economic modelling system. This is followed by an examination of the impacts by industry sector and then by province. Finally, the results are summarized through a set of impact multipliers and return on public investment statistics.

7 A decline in government revenue's share of GDP does not necessarily mean that government revenue has declined. In fact, nominal government revenue is higher for all governments in all shock scenarios than in the baseline.

Dynamic Impacts

For ease of exposition, most of the results of this analysis have been presented either in terms of the impacts over the five-year term of the public infrastructure spending program or as an average of long-term impacts. The C_4SE's provincial economic modelling system does, however, produce results for each year of the analysis. The annual results are presented in this section to help the reader understand the evolution of the economy in response to the increase in investment spending, and to help illustrate different ways of interpreting impact analysis.

Figure 4 displays the year-by-year impact on real GDP growth in Canada over the projection period. Real GDP growth spikes in 2015 when the spending program is introduced, but is then similar to the baseline for the remainder of the program period. Real GDP growth is sharply lower than the baseline in 2020, when the program ends, but is then quite similar to the baseline for the remainder of the projection period. Small differences in growth rates between the shock scenarios can be observed, with real GDP growth in the full and half benefits scenarios exceeding growth in the zero benefits scenario for the years up to 2028 and again after 2036.

Figure 4

Impact of Public Infrastructure Spending on Real GDP Growth in Canada

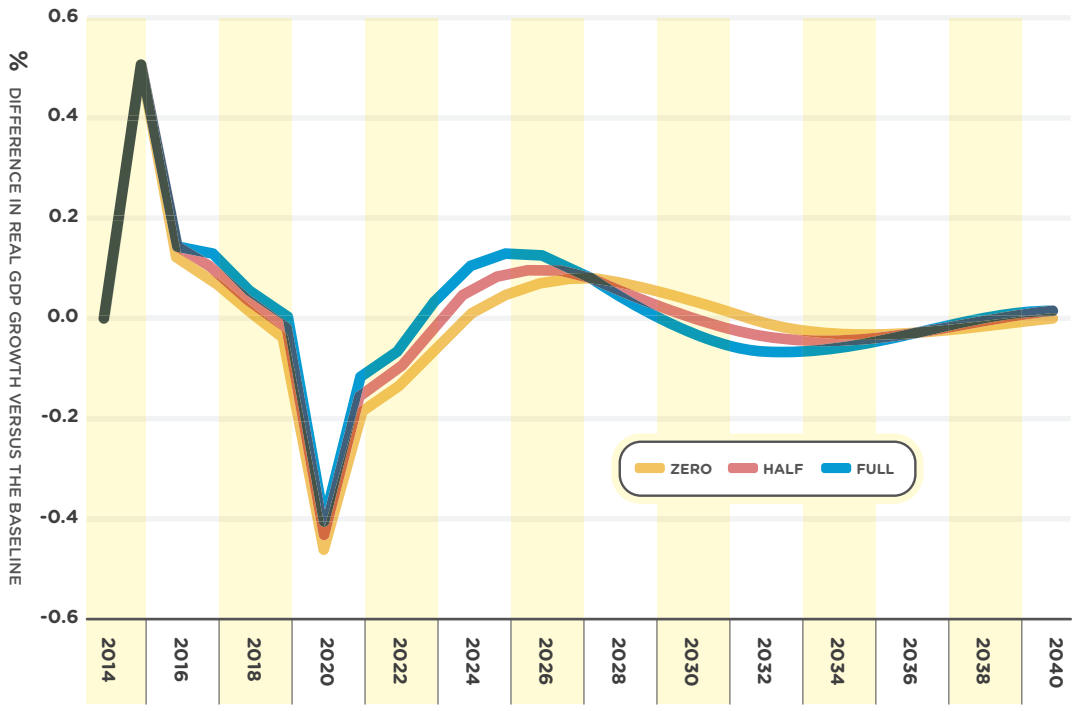
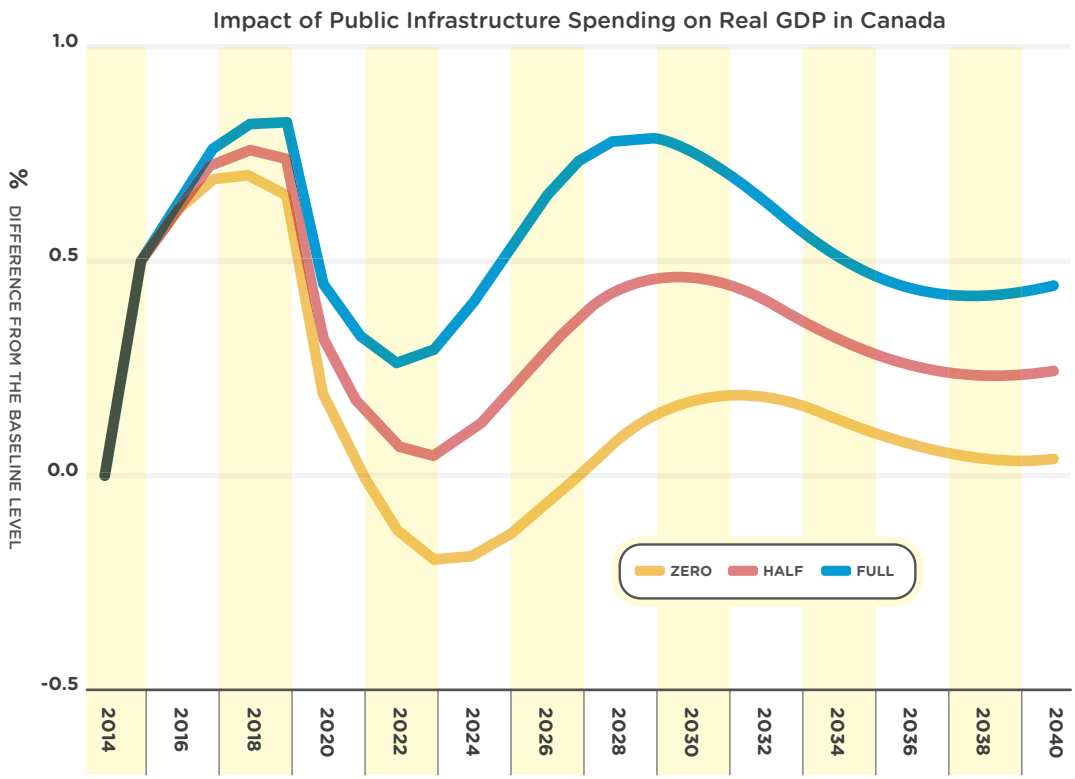


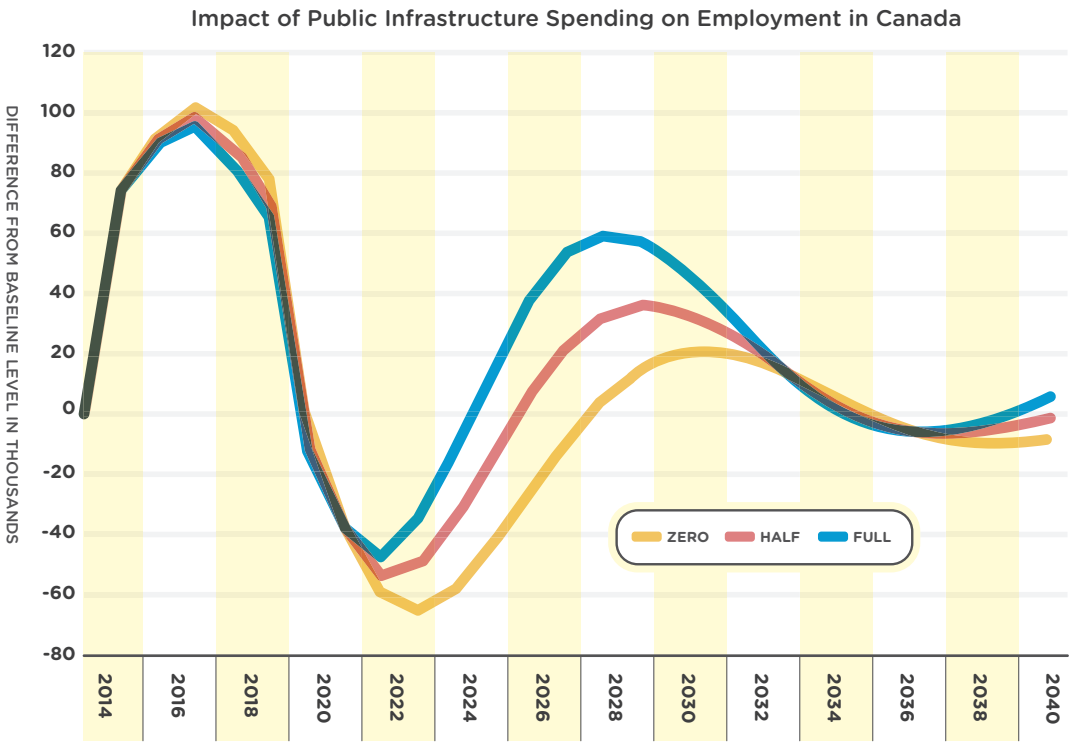
Figure 5



The differences in real GDP growth rates shown in Figure 4 lead to the percentage differences in real GDP from the baseline scenario shown in Figure 5. The increase in real GDP in the zero benefits scenario peaks at 0.7 per cent in 2017–19, and then returns to nearly the same level as the baseline for the remainder of the projection period. The increase in real GDP in the full benefits scenario exceeds that of the zero benefits scenario for the entire projection period: It rises to 0.8 per cent above the baseline in 2017–19, and remains about 0.5 per cent above the baseline at the end of the projection period. Real GDP is therefore permanently higher than the baseline in the full and half benefits scenarios.

The economic cycle seen in Figure 5 is caused by (i) the cessation of the public infrastructure spending program and (ii) the adjustment of the economy to changes in wages and prices arising from the more rapid growth experienced during the program. As discussed previously, the zero benefits case is useful because the benefits of increased private-sector productivity from public infrastructure can be determined by comparing the half and full benefits case impacts against it in each of the figures.

Figure 6



The impact on employment in Canada is shown in Figure 6 and broadly echoes the impact on GDP seen in Figure 5. The public infrastructure program raises employment by more than 100,000 persons in 2017. The impact on employment is quite similar across the three shock scenarios for the first few years before diverging over the years 2023 to 2031, after which time employment in all three shock scenarios is little different from the baseline.

The impact on employment is lower for the full and half benefits cases than for the zero benefits case in the first few years because of the increase in productivity to private business from the increase in public capital. Eventually, the increase in productivity raises incomes and economic activity, leading to an increase in employment. The increase in employment relative to the baseline, however, is only temporary, as the C_4SE's provincial economic modelling system assumes that wage rates adjust to return unemployment rates to their "natural" rate.[8] At the end of the projection period, wage rates—and productivity—will differ across the scenarios, reflecting the differences in GDP shown in Figure 5.

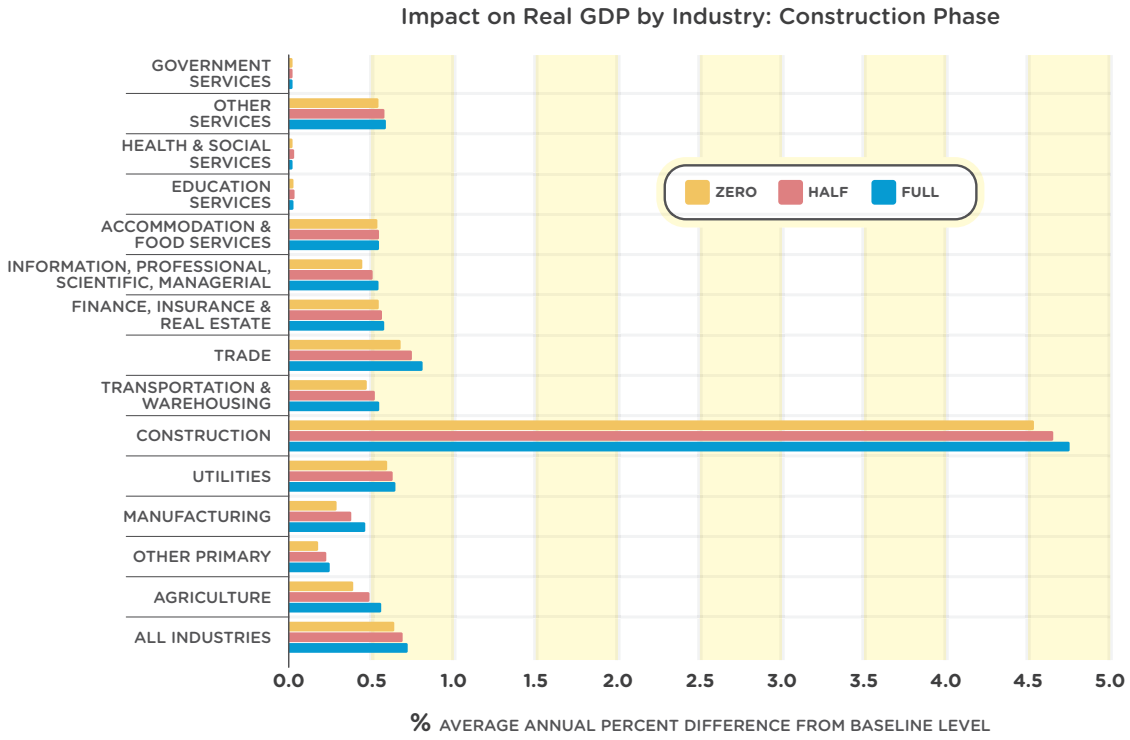
8 The C4SE's provincial economic modelling system ensures that the unemployment rate returns, over time, to its "natural rate." (The "natural unemployment rate" excludes unemployment that is due to cyclical activity in the economy.) This adjustment process involves changes not only in the wage rate, but also 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. Second, changes in population arising from labour migration introduce economic cycles into the model's results as new residential housing, business investment, and even public-sector spending adjust to reflect higher, or lower, population levels.

Industry Impacts

The impacts by industry are shown in Figures 7 and 8. Figure 7 shows the average annual percent difference for each of the public infrastructure spending scenarios compared with the baseline over the five years of the program, while Figure 8 shows the impact over the balance of the projection period.

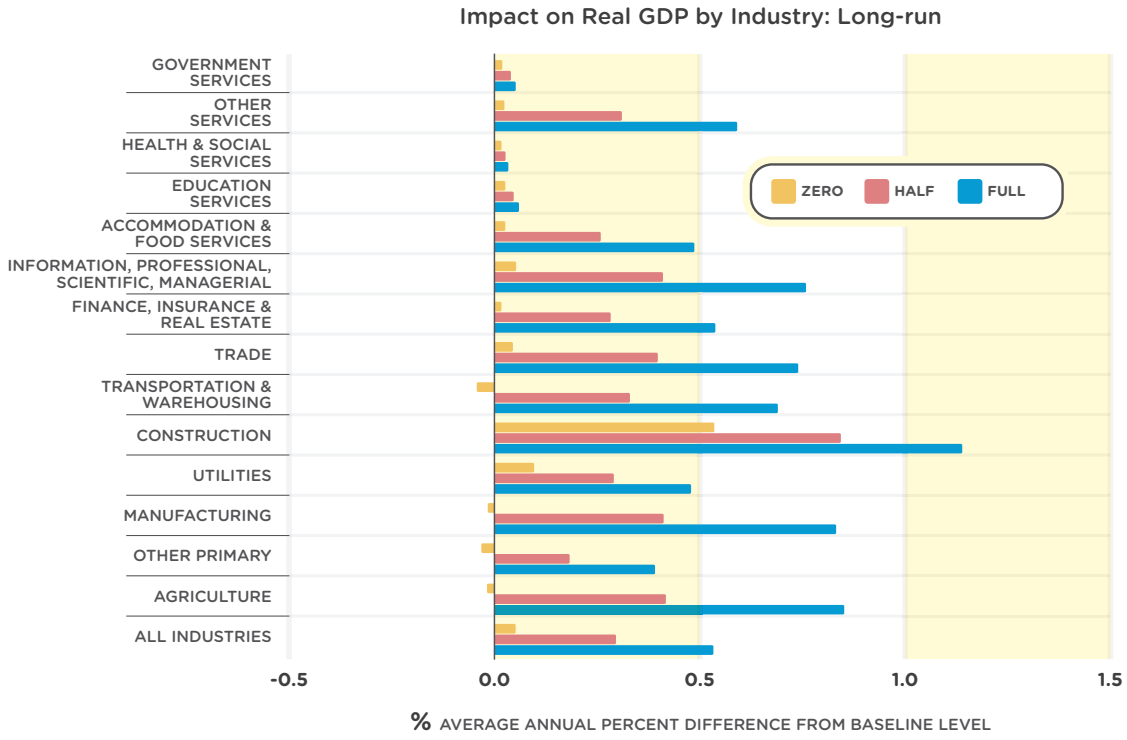
The construction industry is the principal beneficiary of the public infrastructure spending program over the program's five-year period, with activity up by more than 4.5 per cent from the baseline level—representing about half of the overall gain in GDP. The other half of the total gain is spread across all other business-sector industries. The gains to other business sectors are limited to about 0.5 per cent above the baseline, while they are near zero for the public-sector industries. The gains across industries are strongest for the full benefits case and weakest for the zero benefits case.

Figure 7



Over the long run, average annual percent changes in real GDP relative to the baseline are near zero for the zero benefits case for all sectors except the construction industry. Gains in that sector reflect spending to maintain and repair the new public infrastructure. The construction industry remains the largest winner, relative to the baseline, in the half and full benefits scenarios, but the other private-sector industries also experience significant gains. Gains for public-sector industries remain very small.

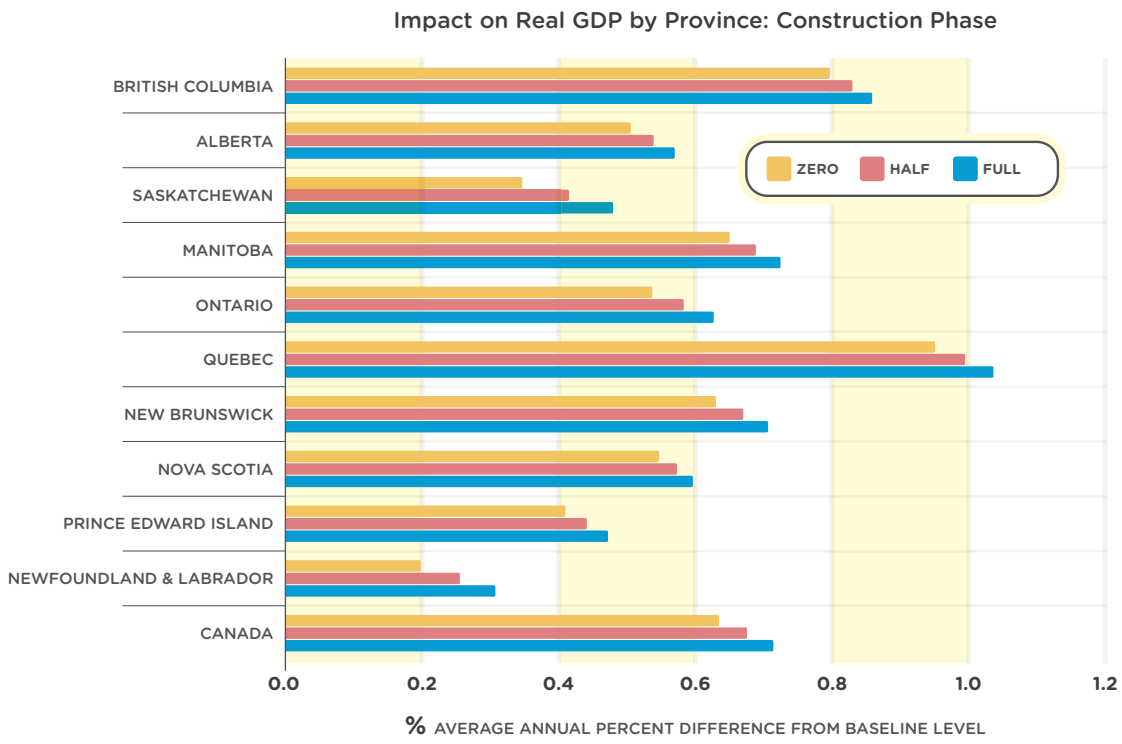
Figure 8



Regional Impacts

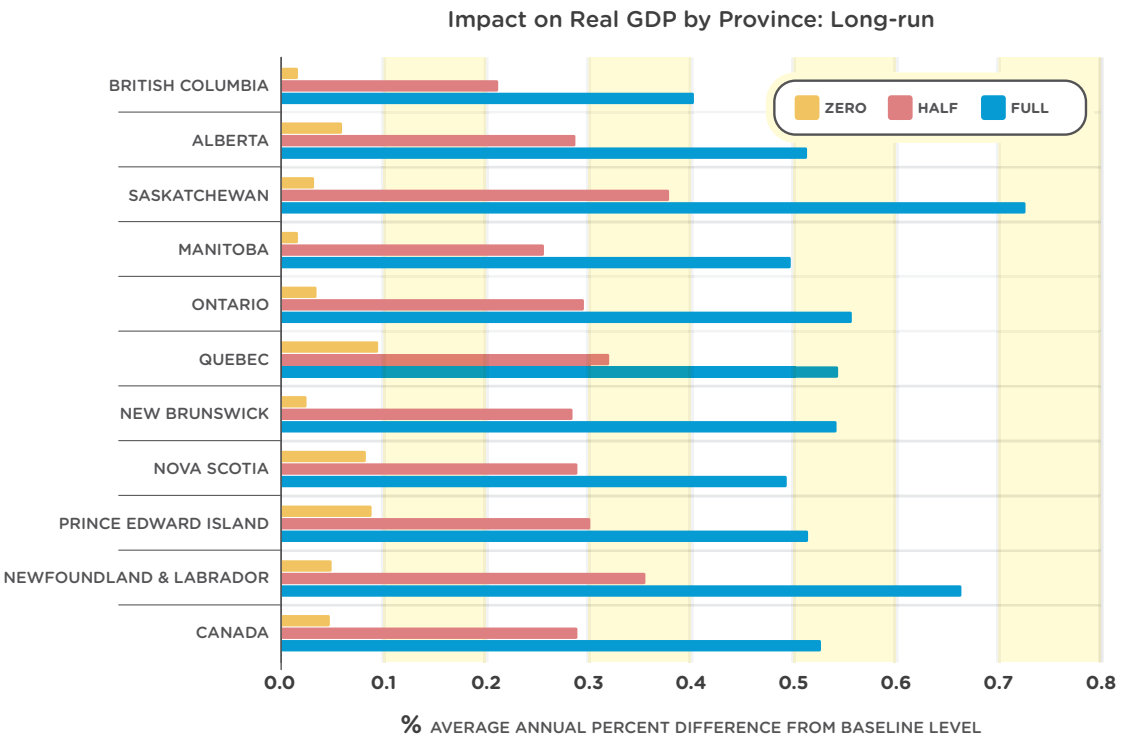
The impacts both nationally and by province are presented in Figures 9 and 10, which show the average annual percent difference from the baseline for each of the public infrastructure spending scenarios for the five-year construction phase and the balance of the projection period, respectively.

Figure 9



As may be expected, the benefits from a national public infrastructure program are felt across the country, although the benefits are larger in some provinces than others. Quebec and British Columbia experience the strongest gains relative to the baseline, while Newfoundland and Labrador and Saskatchewan experience the weakest. The differences in provincial impacts exist for several reasons. Differences in import propensities across provinces, for instance, lead to weaker benefits for those that need to import more goods and services rather than producing them within the province. Differences in GDP shares relative to the population shares used to allocate program spending across the country also have an impact: GDP shares that are higher than the population share will lead to smaller benefits in terms of additional GDP relative to the baseline.

Figure 10



Over the long run, the impact on average annual GDP depends considerably more on the size of the benefits to private industry from public capital than it does on the province. In fact, the standard deviation of impacts across provinces is significantly lower in the long run for each of the three shock scenarios than it is for the scenarios over the five-year construction phase.

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. Economic multipliers are presented in Table 4 and measure the short-term benefits to the economy—in terms of GDP, jobs, investment, and government revenue—of public infrastructure spending. Return on investment statistics are generated to summarize the long-term benefits of public spending and are presented in Table 5. The principal difference between the two types of statistics is that multipliers are measures of "instant gratification," 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 period 2015–19[9] by the change in public infrastructure spending (see Table 2). For GDP, the national multiplier is 1.43. This means that the economy expands by $1.43 for every $1.00 spent on public infrastructure. The value of this multiplier varies significantly across the country—from 0.54 in Newfoundland and Labrador to 1.77 in Quebec—due to the factors discussed for Figure 9.

The impact on employment is typically expressed in terms of jobs per million dollars spent on public infrastructure. The national multiplier is 9.4 jobs per million dollars, and again varies from a low of 3.6 in Newfoundland and Labrador to a high of 13.6 in Quebec.

The non-residential investment multiplier varies in a relatively narrow band from 1.18 in Prince Edward Island to 1.56 in Quebec, and is 1.34 nationally. Since $1 of this increase comes from the public infrastructure spending, the balance of this statistic 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.

Table 4

Public Infrastructure Program: Construction Phase Miltipiers

	Total Impact Multipiers: 2015–2019			
	GDP	Jobs per $ Million	Non-residential Investment	Tax Revenue (Federal/Provincial)
CANADA	1.43	9.4	1.34	0.43
BRITISH COLUMBIA	1.73	11.1	1.30	0.57
ALBERTA	1.76	6.5	1.39	0.00
SASKATCHEWAN	1.07	6.1	1.47	-0.01
MANITOBA	1.31	9.0	1.27	0.39
ONTARIO	1.15	7.6	1.20	0.40
QUEBEC	1.77	13.6	1.56	0.72
NEW BRUNSWICK	1.09	11.0	1.24	0.32
NOVA SCOTIA	0.97	9.7	1.28	0.46
PRINCE EDWARD ISLAND	0.69	7.9	1.18	0.14
NEWFOUNDLAND & LABRADOR	0.54	3.6	1.19	0.03

9 The multipliers shown in Table 4 are generated from the zero benefits case. Multipliers from the full and half benefits cases differ only slightly from those shown. The zero benefits case was chosen for this table because of uncertainty over when private business may realize the benefits from public infrastructure investment.

Federal government revenue rises by $0.43 per $1.00 spent by that level of government (50 per cent of the program is funded by the federal government). At the provincial level of government, the revenue raised per dollar spent on the program varies from near zero in several provinces to $0.57 in British Columbia. The combined provincial multiplier is $0.45 per $1.00 spent, so the revenue recovered by all governments is $0.44 per dollar spent. As these multipliers are less than one, governments finance the program by running higher deficits or lower surpluses.

The low revenue impacts for some provinces require an explanation. The lowest revenue impacts are for the provinces that derive a significant share of their revenue from natural resources—Alberta, Saskatchewan, and Newfoundland and Labrador—and this source of revenue is only marginally affected by the infrastructure spending project. It is also important to note that nominal revenues in the shock scenario are higher for all governments than in the baseline. But, in order to allow relevant comparisons of the relative purchasing power of government revenues in the zero benefits and baseline scenarios, the revenues in both scenarios are restated in 2014 dollar terms. Higher prices in the zero benefits case (see Figure 1) reduce the purchasing power of government revenues in that scenario relative to the baseline, completely eliminating the increase in nominal revenue for some provinces.

Long-Run Return on Investment

The longer-term benefits of public infrastructure spending are assessed through return on investment (ROI) statistics. 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 outcome measures can be assessed. The most common outcomes from economic benefit studies tend to be GDP, employment, and 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 2014 dollars, per dollar of funding (also expressed in 2014 dollars). The second statistic shows the discounted number of jobs per million dollars of spending. The final ROI statistic shows the number of dollars

of additional federal or combined provincial tax revenue, expressed in 2014 dollars, per dollar spent (also expressed in 2014 dollars).

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 the number of potential risks rise as you look further into the future. The 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 modelling 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 discount rate can be used. In these instances, a discount rate of just two or three per cent is often used, but higher uncertainty surrounding the potential benefits from public infrastructure may make it advisable to use a higher discount rate. The benefits based on both five per cent and seven per cent discount rates were assessed to help account for this risk.

The costs and benefits in this study are assessed over the 28-year projection horizon (from 2015 to 2043) in the provincial economic modelling system. Arithmetically extending the projection horizon beyond 50 years leads to stronger, positive results at all discount rates for the GDP, employment, and government revenue ROI statistics. However, because of the potential that other, disruptive technologies could arise in future decades, affecting the assumed long-term returns, this alternative approach was not adopted.

Table 5 shows the ROI statistics associated with the zero benefits case and the half and full benefits cases. Comparing the ROI measures from the zero benefits case with the full and half benefits cases can again help determine the productivity benefits to private business from public infrastructure. The analysis reveals the following:

- The overall ROI is expressed in terms of discounted gross domestic product divided by discounted spending to build

and maintain the new public infrastructure. Discounting future costs and benefits by three per cent yields a ROI of $2.46 and $3.83 per dollar of spending for the half and full benefits cases, respectively. The ROI statistics remain strongly positive even at higher discount rates in the half and full benefits cases.

- A ROI can also be expressed in terms of jobs generated per $1 million of spending to build and maintain new public infrastructure. The half benefits case generates five jobs per $1 million of spending at a three per cent discount rate, but this rises to seven jobs for the full benefits case.

- The return on public investment is expressed in terms of discounted federal or provincial government tax revenues divided by discounted federal or provincial spending to build and maintain the new public infrastructure. Discounting future costs and benefits by three per cent yields a ROI of $0.16 per dollar of federal spending and $0.30 per dollar of provincial spending for the half benefits case. The ROI rises to $0.21 for federal spending and $0.51 for provincial spending for the full benefits case at a three per cent discount rate.

Table 5

Public Investment Spending Return on Investment Statistics

	Discount Rate at:		
	3%	5%	7%
GDP PER $ OF SPENDING			
ROI BASED ON ZERO BENEFITS	1.10	1.11	1.12
ROI BASED ON HALF BENEFITS	2.46	2.28	2.13
ROI BASED ON FULL BENEFITS	3.83	3.46	3.14
JOBS PER $ MILLION OF SPENDING			
ROI BASED ON ZERO BENEFITS	3.0	3.6	4.1
ROI BASED ON HALF BENEFITS	5.0	5.4	5.6
ROI BASED ON FULL BENEFITS	7.1	7.1	7.1
FEDERAL TAX REVENUE PER $ OF SPENDING			
ROI BASED ON ZERO BENEFITS	0.10	0.14	0.17
ROI BASED ON HALF BENEFITS	0.16	0.19	0.22
ROI BASED ON FULL BENEFITS	0.21	0.24	0.26
PROVINCIAL TAX REVENUE PER $ OF SPENDING			
ROI BASED ON ZERO BENEFITS	0.04	0.10	0.15
ROI BASED ON HALF BENEFITS	0.30	0.32	0.33
ROI BASED ON FULL BENEFITS	0.51	0.50	0.49

SUMMARY AND OBSERVATIONS

Since productive public infrastructure reduces costs for private businesses, 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 elasticity estimates from Harchaoui and Tarkhani, are credible and represent the benefits that should accrue from spending on public infrastructure. Although the five-year, $50 billion program size is arbitrary, it is evident that a program of this scale is required to begin to address the estimated $171.8 billion cost of replacing the municipal assets rated fair, poor, or very poor condition across the country. Because there is always a risk that such a large infrastructure program could be administered inefficiently, leading the economy to realize fewer benefits (perhaps as low as the half benefits case results), it is imperative to structure such programs so they are designed and managed well.

The short-run economic benefits include a GDP multiplier of 1.43, 9.4 jobs generated per million dollars spent, and $0.44 of government revenue recovered per dollar spent. The increase in domestic economic activity, particularly new construction-sector jobs, becomes more attractive in a slow-growth environment riddled with external risks to our economy, such as low oil prices and uncertain markets for our oil and gas, weakness with the ongoing potential for crisis in Europe, and uncertainty in the United States.

Over the long run, the return on investment to GDP from spending on public capital, assuming a three per cent discount rate, lies between 2.46 and 3.83 for the half and full benefits scenarios. This result is easily strong enough to justify a public infrastructure spending initiative and still remains high when higher discount rates are assumed. While federal government revenue recovered is between $0.16 and $0.21, and provincial government revenue is between $0.30 and $0.51, the long-run fiscal impact is less significant than this would suggest. While deficits remain in the half benefits case (with a $1.0 billion average annual increase measured in 2014 dollars for the federal government and a $2.2 billion increase for provincial governments), they shrink in the full benefits case: $0.6 billion a year on average for the federal government and $1.1 billion for the provincial governments. When expressed as a share of GDP, the average annual deficit-to-GDP ratio for the federal government rises 0.04 per cent in the half benefits case and falls 0.02 per cent in the full benefits case, while for provincial governments it rises 0.08 per cent in the half benefits case and falls 0.04 percent in the full benefits case. The overall long-run impact on both

federal and provincial governments is therefore likely to be very small, and may even be positive.

Some critics may note that the long-run increase in employment of between five and seven 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 modelling system, where changes in wage rates and migration force the unemployment rate to adjust towards its natural rate over time. While employment gains may be limited, businesses are more productive and competitive, and workers earn higher real wages: up 0.4–0.6 per cent a year on average in the half and full benefits cases 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 by up to $0.34 per dollar of spending in the near term, and by $0.50–$1.00 in the 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 more private-sector investment, a more productive economy, and a higherstandard of living—and all are achieved without significant long-term fiscal consequences to federal or provincial governments.

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, allowing our public infrastructure to continue to decay imposes costs at least equal but opposite to the benefits estimated in this study. The competitiveness of private businesses in Canada is tied to the quality of our public assets, so a significant and sustained public infrastructure spending initiative is required if households and businesses are to continue to enjoy the high standard of living provided by our public infrastructure system.

APPENDIX A: CONTRIBUTION OF PUBLIC CAPITAL AT THE INDUSTRY LEVEL

The following table can be found in Harchaoui and Tarkhani's paper (Table 5, p.17), and provides a summary of their empirical results. The industry cost elasticities (η_{CG}) indicate the percentage change in the total private cost of producing a given level of output that is associated with a one per cent 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 the transportation and wholesale and retail trade sectors. The weighted average aggregate impact on business costs is to lower them by 0.06 per cent for every one per cent increase in public capital.

Table 6

Public Investment Spending Return on Investment Statistics

	Discount Rate at:			
	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
BEVERAGE	-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 TEXTILE	-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 FIXTURE	-0.013	1.023	1.064	0.013
PAPER AND ALLIED PRODUCTS	-0.034	1.067	1.125	0.036
PRINTING PUBLISHING AND ALLIED	-0.030	1.065	1.140	0.032
PRIMARY METAL	-0.052	1.047	1.157	0.055
FABRICATED METAL PRODUCTS	-0.049	1.075	1.171	0.053
MACHINERY INDUSTRY (EXCEPT ELECTRICAL MACHINERY)	-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 one per cent 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 one per cent increase in all inputs including public capital; and η_{CG} is the marginal productivity of public capital, or the effect on output of a one per cent increase in public capital holding other inputs constant.

APPENDIX B: C_4SE PROVINCIAL ECONOMIC MODELLING SYSTEM

The C_4SE's provincial economic modelling 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. The national model 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 modelling system is to produce medium- to long-term projections of the provincial economies and conduct simulation studies that require industry and demographic detail.

This modelling system consists of a set of provincial and territorial macroeconomic models that are linked through trade, financial markets, and interprovincial migration. The impact on the supply chain—in terms of output and employment—is fully captured by the multi-sector model, which incorporates the purchasing patterns from the current input–output tables. But, unlike an input–output model, a dynamic macroeconomic model also considers the impact that the change in economic activity has on suppliers' investment decisions.

The model produces impacts on employment, labour income, value-added output, productivity, investment, and exports for at least 14 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
- Other Primary *(detail varies by province)*
- Manufacturing *(detail varies by province)*
- Construction
- Utilities
- Transportation & Warehousing
- Wholesale & Retail Trade
- Finance, Insurance, & Real Estate
- Professional, Scientific, & Management Services
- Accommodation & Food
- Health Services
- Other Services
- Education Services
- Government Services

The model incorporates partial 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–U.S. 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 subnational models, the provincial models assume 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 each province.

In subnational 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, which 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 on prices, interest rates, and exchange rates. The entire national economy therefore adjusts over time to the initial shock.

Summary of C_4SE Winter 2014–15 Outlook

The provincial economic modelling system models and forecasts that were used in this analysis were released in January 2015. The outlook is summarized in the following two tables. The outlook incorporates lower prices for oil and other commodities plus weaker economic growth for Canada's key trading partners. The slump in oil prices slows economic growth in Alberta, Saskatchewan, and Newfoundland and Labrador this year. Economic growth is expected to pick up again for the last few years of the decade, but then slows—driven by demographic changes—over the long term.

Table 7

C_4SE Economic Outlook: Winter 2014–15

	Discount Rate at:							
	2015	2016	2017	2018	2019	2020	AVERAGE 2015–20	AVERAGE 2020–40
GDP GROWTH BY PROVINCE:	%	%	%	%	%	%	%	%
CANADA	1.9	2.3	2.4	2.6	2.1	1.8	2.2	1.5
BRITISH COLUMBIA	2.4	3.2	3.6	3.9	2.8	2.1	3.1	1.7
ALBERTA	0.6	1.5	1.7	2.5	2.9	2.5	2.2	1.5
SASKATCHEWAN	1.4	2.7	2.1	2.2	1.3	0.3	1.7	0.9
MANITOBA	2.5	3.6	2.0	1.4	1.5	1.3	2.0	1.6
ONTARIO	2.7	2.4	2.3	2.3	1.7	1.6	2.0	1.6
QUEBEC	1.6	1.9	2.7	2.7	2.1	1.7	2.2	1.7
NEW BRUNSWICK	1.3	2.1	2.5	2.2	1.5	1.6	2.0	0.8
NOVA SCOTIA	1.6	2.4	2.3	2.0	1.4	1.0	1.8	0.6
PRINCE EDWARD ISLAND	1.9	2.9	2.8	2.1	2.2	1.6	2.3	1.3
NEWFOUNDLAND & LABRADOR	1.0	1.6	0.7	5.4	2.2	2.4	2.4	0.1
EMPLOYMENT GROWTH BY PROVINCE:	%	%	%	%	%	%	%	%
CANADA	0.9	1.2	1.4	1.5	1.0	0.7	1.1	0.6
BRITISH COLUMBIA	1.5	2.1	2.2	2.2	1.8	1.0	1.9	0.6
ALBERTA	0.6	1.2	1.4	2.1	2.1	1.8	1.7	0.9
SASKATCHEWAN	0.7	1.6	1.3	1.5	0.6	-0.1	1.0	0.4
MANITOBA	0.9	1.9	1.6	1.2	0.9	0.7	1.3	0.8
ONTARIO	1.0	1.1	1.1	1.2	0.6	0.5	0.9	0.5
QUEBEC	0.6	0.7	1.5	1.4	0.7	0.4	0.9	0.6
NEW BRUNSWICK	0.3	1.0	1.4	1.2	0.5	0.2	0.9	-0.4
NOVA SCOTIA	0.8	1.1	1.3	0.8	0.2	-0.3	0.6	-0.6
PRINCE EDWARD ISLAND	1.2	2.1	2.1	1.3	1.1	0.5	1.4	0.3
NEWFOUNDLAND & LABRADOR	-0.9	0.8	-0.9	0.8	0.7	1.3	0.6	0.2
EMPLOYMENT GROWTH BY INDUSTRY:	%	%	%	%	%	%	%	%
AGRICULTURE	1.3	-0.7	0.2	0.0	-0.4	-0.8	-0.3	-0.8
OTHER PRIMARY	0.7	-0.4	-0.1	-0.2	-0.2	-0.2	-0.2	-0.8
MANUFACTURING	1.2	1.4	1.6	1.2	0.0	-0.9	0.7	-0.9
UTILITIES	-0.3	0.8	1.5	1.2	0.9	0.5	1.0	0.3
CONSTRUCTION	-0.8	1.3	0.7	1.8	1.1	1.0	1.2	-0.4
TRANSPORTATION & WAREHOUSING	1.8	1.6	1.6	1.5	0.8	0.1	1.1	0.2
WHOLESALE & RETAIL TRADE	0.7	0.9	1.5	1.7	1.1	0.7	1.2	0.4
FINANCE, INSURANCE & REAL ESTATE	1.2	1.2	1.3	1.4	0.8	0.5	1.0	0.4
INFORMATION & PROFESSIONAL SERVICES	1.0	1.6	1.7	1.8	1.0	0.5	1.3	0.3
ACCOMMODATION & FOOD SERVICES	1.1	1.3	1.6	1.5	0.8	0.6	1.2	0.5
EDUCATION SERVICES	-0.7	-0.8	-0.3	-0.2	0.1	0.4	-0.2	1.1
HEALTH & SOCIAL SERVICES	2.1	2.2	2.5	2.4	2.5	2.5	2.4	2.0
OTHER SERVICES	1.1	1.4	1.6	1.6	1.0	0.6	1.2	0.4
GOVERNMENT SERVICES	0.3	0.7	0.9	1.0	1.1	1.2	1.0	1.2

Table 8

C_4SE Economic Outlook: Winter 2014–15

	2015	2016	2017	2018	2019	2020	AVERAGE 2015–20	AVERAGE 2020–40
ECONOMIC PERFORMANCE								
REAL PER CAPITA GDP (%)	0.8	1.2	1.2	1.4	1.0	0.8	1.1	0.8
REAL PER CAPITA DISPOSABLE INCOME (%)	0.7	0.7	1.0	1.0	1.0	1.4	1.0	1.1
LABOUR PRODUCTIVITY (%)	1.0	1.1	1.0	1.1	1.1	1.1	1.1	1.0
DEMOGRAPHICS, LABOUR & HOUSING								
POPULATION (%)	1.1	1.1	1.1	1.1	1.1	1.2	1.1	0.7
NET IMMIGRATION (THOUSAND)	247	262	269	280	293	313	270	266
UNEMPLOYMENT RATE (%)	7.0	6.8	6.5	6.1	5.9	6.0	6.5	5.7
HOUSING STARTS (THOUSAND)	195	200	204	213	217	222	206	166
EXTERNAL & GOVERNMENT BALANCES								
REAL TRADE BALANCE ($ 2007 BILLION)	-14	0	18	22	21	19	10	17
NOMINAL TRADE BALANCE ($ BILLION)	-47	-29	0	13	12	8	-10	14
FEDERAL NET LENDING ($ BILLION)	-10	-7	-6	-2	-1	-1	-5	-1
PROVINCIAL NET LENDING ($ BILLION)	-35	-27	-22	-17	-17	-18	-24	-39
WAGES & PRICES								
CONSUMER PRICE INDEX (%)	1.5	2.4	1.8	2.0	1.8	1.9	2.0	2.2
WAGE RATE (%)	2.6	2.8	3.1	3.5	3.1	2.8	3.1	2.9
UNIT LABOUR COSTS (%)	0.0	1.8	3.4	1.7	1.6	1.6	2.0	2.0
FINANCIAL MARKETS								
3-MONTH T-BILL RATE (%)	1.15	2.30	3.25	3.68	3.98	3.75	2.87	4.14
10-YEAR GOC BOND RATE (%)	3.05	4.10	4.55	4.58	4.98	5.15	4.25	5.81
EXCHANGE RATE (US CENTS PER CAD)	85.2	85.5	85.6	86.1	86.2	86.1	85.7	87.4

APPENDIX C: SCENARIO RESULTS

A detailed summary of the economic and fiscal impacts for each public infrastructure spending scenario (zero, half and full benefits for selected time periods) compared to the baseline results are available upon request. Please contact the research department of the Broadbent Institute at research@broadbentinstitute.ca.

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