THE ECONOMIC BENEFITS OF PUBLIC INFRASTRUCTURE SPENDING IN BRITISH COLUMBIA

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About this Study

This report was prepared for The Broadbent Institute by The Center for Spatial Economics. 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.

The analysis estimates the economic benefits of public infrastructure spending in British Columbia 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 British Columbia 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 British Columbia.

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.

Executive Summary

There is a broad consensus that Canada's public infrastructure has deteriorated over the last few decades. Issues with traffic congestion, inadequate public transportation, sewer collapse and sinkholes regularly make media headlines and have gone from being inconvenient to a serious impediment to economic activity. The Broadbent Institute is encouraging all levels of governments across the country to focus on developing the country's infrastructure.

This report examines the economic benefits of three possible public infrastructure spending plans in British Columbia. The three plans involve 5-year cumulative spending commitments by the provincial government of $5, $7 and $10 billion respectively. The benefits from a public infrastructure program arise from the direct program spending but then extend beyond this direct impact. Public capital promotes long-term economic growth and productivity as productive public infrastructure reduces costs for private businesses providing a compelling case for public funding of this capital.

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

- In the short-run, GDP rises $1.78 per dollar of spending, 9.6 jobs are generated per million dollars spent and $0.29 of each dollar spent by government is recovered in additional provincial tax revenue
- Over the long-term, the discounted present value of GDP generated per dollar of public infrastructure spending (ROI) lies between $1.42 and $2.09
- Private sector investment rises
- Businesses are more productive and competitive in international markets
- Real wages rise, providing a higher standard of living

Table 1

British Columbia Public Infrastructure Spending: Summary of Benefits			
Impact per dollar of public infrastructure spending	Short-run Total Impact Multiplier	Long-run Return on Investment	
		Half Benefits	Full Benefits
GDP per $ of spending	1.78	1.42	2.09
Non-Residential investment per $ of spending	1.35	0.84	1.04
Jobs per $million of spending	9.6	1.1	1.1
BC Gov't tax revenue per $ of spending	0.29	0.14	0.19

Productive public infrastructure reduces costs for private businesses – boosting GDP by up to $2.09 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.

The C_4SE cautions against viewing public infrastructure spending as tool to counter the business cycle.

Public infrastructure funding decisions should be based on long-term benefits and avoid funding projects that yield less long-term utility to the economy so as to ensure that the spending does not yield reduced long-term benefits to output or employment while saddling the economy with additional debt.

Study Methodology

The analysis consists of seven scenarios which were 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. 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 three other sets of scenarios reflect changes in economic activity arising from the public infrastructure spending program. Each set of scenarios is constructed for cumulative 5-year spending programs of $5, $7 and $10 billion. 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 and British Columbia 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 reader should note that, like other reports, this study only considers 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 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, 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 British Columbia (2011) are tied to the quality of public assets so a significant and sustained public infrastructure spending initiative is required if households and businesses are to continue to enjoy a high standard of living.

British Columbia's Infrastructure Spending Options

There is a broad consensus that Canada's public infrastructure has deteriorated over the last few decades. Issues with traffic congestion, inadequate public transportation, sewer collapse and sinkholes regularly make media headlines and have gone from being inconvenient to a serious impediment to economic activity. Many governments across the country are now committed to addressing issues with public infrastructure with increased spending to expand, replace or repair public assets.

Lemire and Gaudreault (2006) estimated that in 2003 Canada's road and highway network had over 50 percent of its useful life behind it while federal and provincial bridges had passed the halfway mark of their useful life. Municipal bridges fared a little better with 41 percent of their useful lives behind them. More recently, Guy Félio (2012) prepared a report for the Federation of Canadian Municipalities which 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.

The Broadbent Institute is encouraging all levels of governments across the country to maintain this focus on developing the nation's infrastructure (Centre for Spatial Economics, 2015). This report examines the economic benefits of three possible public infrastructure spending plans in British Columbia. The three plans involve 5-year cumulative spending commitments by the provincial government of $5, $7 and $10 billion respectively.

While it is expected that this spending will improve the quality of life in British Columbia – for example by reducing traffic congestion, green house gas emissions, or reducing road closures and property damage from infrastructure failure – it is also important to understand the economic and fiscal consequences of this spending. This study uses the C_4SE's provincial economic modeling system to provide an assessment of the near-term and long-run economic and fiscal impacts of this spending.

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, 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 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. 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. 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.[1] Nadiri and Mamuneas (1994) use the cost function approach to investigate the impact of public capital on the cost structure of the 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.

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 2010).

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 does not stop with 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

[1] 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.

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.[2]

This paper uses the findings from Harchaoui and Tarkhani to estimate the economic benefits of the three public infrastructure spending options using the C_4SE's provincial economic modeling system. 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 provide summary measures of the results. The paper concludes with some observations based on the results.

[2] 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.

Methodology and Assumptions

This section reviews the methodology and assumptions required to assess the benefits of public infrastructure spending in British Columbia. The benefits of a public infrastructure program – which accrue principally to the construction sector[3] – arise from the direct program spending and beyond, with public capital promoting economic growth and productivity. The reader should note that current government spending (excluding debt service charges) is not directly affected by infrastructure spending. 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. The study, therefore, assumes that any improvements or additions to the stock of institutional buildings either replace decommissioned buildings or meet anticipated increases in demand arising from changes in population.

The private industry cost elasticities estimated by Harchaoui and Tarkhani are used to reduce production costs by the 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 benefits to industry in terms of reduced cost 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. A lack of repair and replacement spending after the 5-year program period would, however, lead to a deterioration in the cost benefits to private industry. 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 Modeling Uncertainty

The private industry cost elasticities estimated by Harchaoui and Tarkhani 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 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**.[4] The **half benefits case** scenario 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 lower economic necessity or value. Economists refer to this

[3] A table of sectoral impacts is included in Appendix C

[4] 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.

phenomenon as "diminishing marginal return on investment." The **full benefits case** is based on the full value of the estimated cost elasticities.

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. The model is described in more detail in Appendix B.

The analysis consists of seven scenarios. 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 six scenarios reflect changes in economic activity arising from the public infrastructure spending program and are grouped into three sets of shock scenarios. The other scenarios are the **half** and **full benefits cases** which assume respectively that the 5-year cumulative $5 billion public infrastructure program provides either half or all the benefits to private business estimated by Harchaoui and Tarkhani. The **half** and **full benefits case** scenarios are then repeated with 5-year cumulative spending programs of $7 and $10 billion.

Table 2

British Columbia Public Infrastructure Spending: Summary of Economic Impacts						
Difference from the Baseline Scenario	Spending of $5 billion		Spending of $7 billion		Spending of $10 billion	
	Short-run Average (5 year)	Long-run Average (20 years)	Short-run Average (5 year)	Long-run Average (20 years)	Short-run Average (5 year)	Long-run Average (20 years)
GDP (millions of 2016 dollars)						
Half benefits to private business	1726	573	2417	803	3452	1147
Full benefits to private business	1790	1098	2506	1537	3580	2195
Non-residential Investment (millions of 2016 dollars)						
Half benefits to private business	1302	227	1822	318	2603	454
Full benefits to private business	1350	366	1890	512	2700	732
Employment (thousands)						
Half benefits to private business	9.8	-2.2	13.7	-3.0	19.6	-4.3
Full benefits to private business	9.2	-2.0	12.9	-2.8	18.4	-4.0

The results are conducted under the maintained assumption that ongoing provincial public infrastructure spending is sufficient to maintain the stock of public capital at the level above the baseline attained at the end of the 5-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. Assuming 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 2 summarizes the economic benefits from these scenarios by comparing activity in the six public infrastructure spending scenarios against the baseline scenario.

The total impacts for the full and half benefits cases in Table 2 include the **direct** increase in public infrastructure spending plus the **indirect** impact on British Columbia suppliers to the construction companies of 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 larger than the direct increase in spending.

The average annual impact on GDP, measured in millions of 2016 dollars, during the 5-year $5 billion spending program is between $1.7 and $1.8 billion for the half and full benefits cases higher than in the baseline scenario. Non-residential fixed investment also rises, relative to the baseline, over this period with average annual increases of between $1.3 and $1.4 billion. It is worth noting that the average annual increase in fixed non-residential investment is higher than the public infrastructure program spending of $1.0 billion a year (expressed in 2016 dollars) for both the shock scenarios as also found by Harchaoui and Tarkhani. The increase in average annual employment relative to the baseline is between 9 and 10 thousand for the two shock scenarios as higher productivity in the full benefits case scenario slightly reduces the increase in employment relative to the half benefits case scenario. In terms of person-years of work, the $5 billion infrastructure spending program generates between 46 and 49 thousand over the 5 years of program spending.

After the 5-year $5 billion infrastructure program ends, reductions in business costs incorporated in the half and full benefits cases lead to average annual increases in GDP (measured in 2016 dollars) relative to the baseline of between $0.6 and $1.1 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 $0.2 billion relative to the baseline scenario while the full benefits case raises it by $0.4 billion. Finally, the long-run impact on employment is down by about around 2,000 for both the shock scenarios relative to the baseline. As a result, labour productivity is up for both shock scenarios relative to the baseline.

The output, investment and employment impacts for the 5-year cumulative $7 and $10 billion public infrastructure spending plans vary proportionally to those for the $5 billion plan discussed above.

Table 3

British Columbia Public Infrastructure Spending: Summary of Fiscal Impacts						
Difference from the Baseline Scenario	Spending of $5 billion		Spending of $7 billion		Spending of $10 billion	
	Short-run Average (5 year)	Long-run Average (20 years)	Short-run Average (5 year)	Long-run Average (20 years)	Short-run Average (5 year)	Long-run Average (20 years)
BC Government Revenue (millions of 2016 dollars)						
Half benefits to private business	291	18	408	25	582	36
Full benefits to private business	290	58	406	81	580	115
BC Government PA Deficit (share of GDP)						
Half benefits to private business	-0.04	0.18	-0.06	0.24	-0.09	0.32
Full benefits to private business	-0.04	0.16	-0.06	0.20	-0.10	0.27

The fiscal implications for the provincial government are presented in Table 3. Provincial government revenues, measured in 2016 dollars, rise an average of $0.3 billion a year relative to the baseline for both shock scenarios during the 5-year $5 billion spending program. After the 5-year program ends, the average annual change in provincial government revenue is quite small relative to the baseline. The revenue response for the $7 and $10 billion spending plans varies proportionally to those for the $5 billion plan.

The province's fiscal balance, on a Public Accounts (PA) basis, improves slightly as a share of GDP for both shock scenarios relative to the baseline during the 5-year $5 billion spending program. However, the average annual balance deteriorates, as a share of GDP, 0.2% after the 5-year spending program ends as the amortized cost of the infrastructure spending is realized.

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.[5] 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 5-year infrastructure spending period[6] by the change in public infrastructure spending. For GDP, the short-run multiplier is 1.78. This means that the economy expands by $1.78 for every $1.00 spent on public infrastructure.

[5] 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.

[6] The multipliers shown in Table 4 are generated from the average of the full and half benefits case impacts.

Table 4

British Columbia Public Infrastructure Spending: Summary of Benefits			
Impact per dollar of public infrastructure spending	Short-run Total Impact Multiplier	Long-run Return on Investment Half Benefits	Full Benefits
GDP per $ of spending	1.78	1.42	2.09
NR investment spending per $ of spending	1.35	0.84	1.04
Jobs per $million of spending	9.6	1.1	1.1
BC Gov't tax revenue per $ of spending	0.29	0.14	0.19

The impact on employment is typically expressed in terms of jobs per million dollars spent on public infrastructure. The short-run employment multiplier is 9.6 jobs per million dollars.

The non-residential investment multiplier is 1.35 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.

British Columbia' provincial government revenue rises $0.29 per $1.00 of program spending. As these multipliers or revenue recovery rates are less than one, the provincial government finances the program by running higher deficits or lower surpluses.

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 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 discount rate can be used. In these instances a discount rate of just 3% 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 Provincial Economic Modeling System (from 2016 to 2040). Arithmetically extending the projection horizon out beyond 2040 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 the potential that global events or other, disruptive technologies could arise in future decades affecting the assumed long-term returns.

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 2016 dollars, per dollar of funding (also expressed in 2016 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 Provincial tax revenue, expressed in 2016 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 gross domestic product divided by discounted spending to build and maintain the new public infrastructure. Discounting future costs and benefits by 3% yields a ROI of between $1.42 and $2.09 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. Both spending scenarios generate 1 job per $1 million of funding at a 3% discount rate.
- The return on public investment is expressed in terms of discounted provincial government tax revenues divided by discounted program spending to build and maintain the new public infrastructure. Discounting future costs and benefits by 3% yields a provincial tax revenue ROI of between $0.14 and $0.19 per dollar of spending for the half and full benefits cases respectively.

Over the long-term, the government will collect between $0.14 and $0.19 in revenue for every dollar it spends. The public infrastructure spending does, however, stimulate private sector investment and generate significant increases in the province's GDP and productivity.

Summary and Observations

A sustained public infrastructure spending program can lay the foundation for future growth and prosperity in British Columbia. 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, 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 1.78, 9.6 jobs generated per million dollars spent, and $0.29 of provincial government revenue recovered per dollar spent. The increase in domestic economic activity, particularly new construction sector jobs, can be attractive in a slow growth environment; prompting various proponents of public infrastructure spending to argue that it can be useful in countering the business cycle over the short-term. The C_4SE considers this to be a weak reason for this spending and that public infrastructure funding decisions should be based on long-term needs so as to deliver lasting benefits. Correctly timing fiscal policy to counter the economic cycle is difficult. If projects are rushed so as to boost short-term demand with limited thought given to their long-term utility to the economy, then there is a significant risk of not realizing the outcomes described by the full benefits case scenario since the spending yields less long-term benefits to output or employment while saddling the economy with additional debt. Infrastructure spending must be directed towards projects that yield long-term benefits to the economy.

Over the long-run, the return on investment to GDP from spending on public capital, assuming a 3% discount rate, lies between 1.4 and 2.1 for the half and full benefits case scenarios. This means that every dollar invested in infrastructure results in an increase of up to $2 in real GDP over the long-term. This result is strong enough to justify a public infrastructure spending initiative and still remains high when higher discount rates are assumed. Provincial government revenue recovered is between $0.14 and $0.19 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 just 1 job 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. While employment gains may be limited, businesses are more productive and competitive and workers earn higher real wages: up between 0.4 and 0.5% after the 5-year spending program ends 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.

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 British Columbia are tied to the quality of its 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 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 5

Translog Cost Function Elasticities				
	η_{CG}	$1/\eta$	$1/\eta^*$	η_{YG}
Agricultural and related service	-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 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. 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 modeling 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 inter-provincial 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, in contrast to an input-output model, a dynamic macroeconomic model also considers 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 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-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 British Columbia 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 British Columbia 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.

Appendix C: Sectoral Impacts

British Columbia Public Infrastructure Spending: Sectoral Impacts												
Difference from the Baseline Scenario in Millions of 2016 Dollars	Spending of $5 billion				Spending of $7 billion				Spending of $10 billion			
	Short-run Average		Long-run Average		Short-run Average		Long-run Average		Short-run Average		Long-run Average	
	Half Benefits	Full Benefits	Half Benefits	Full Benefits	Half Benefits	Full Benefits	Half Benefits	Full Benefits	Half Benefits	Full Benefits	Half Benefits	Full Benefits
All Industries (basic prices)	**1,583**	**1,642**	**531**	**1,016**	**2,216**	**2,299**	**743**	**1,422**	**3,165**	**3,284**	**1,061**	**2,031**
Agriculture	6	7	5	10	9	10	6	14	13	14	9	21
Other Primary	73	82	47	109	103	115	65	153	146	164	93	218
Manufacturing	66	77	68	157	92	108	96	219	131	154	137	314
Utilities	26	27	10	17	37	38	14	24	53	54	20	35
Construction	748	766	132	181	1,047	1,072	185	253	1,496	1,531	265	361
Transportation & Warehousing	56	60	39	92	79	84	54	128	113	120	77	183
Trade	177	188	77	148	248	263	107	207	354	375	153	295
Finance, Insurance & Real Estate	161	161	47	92	225	225	66	128	322	322	95	183
Information, Professional, Scientific, Managerial	128	134	64	128	179	188	90	179	255	268	129	255
Accommodation & Food Services	32	31	10	20	44	43	14	28	63	62	20	39
Education Services	7	6	-2	-3	9	9	-3	-4	13	12	-4	-5
Health & Social Services	5	5	-1	-2	7	7	-1	-3	11	10	-2	-4
Other Services	93	94	35	70	131	132	49	97	187	188	70	139
Government Services	4	4	-1	-2	6	6	-1	-2	8	8	-2	-3

Note: sector impacts in this table are reported at basic prices; all other GDP impacts used in this study are reported at market prices