The Economic Impact of Public Infrastructure in Ontario

ECONOMIC PERFORMANCE AND TRENDS
Preface

This research was undertaken by The Conference Board of Canada for Infrastructure Ontario. In keeping with Conference Board guidelines for financed research, the design and method of research, as well as the content of this study, were determined solely by the Conference Board. The research was conducted by Jacqueline Johnson (Economist) and Kip Beckman (Principal Economist) in the Conference Board’s Economic Forecasting and Analysis group. Pedro Antunes, Director of the Board’s National and Provincial Forecast group, contributed and oversaw research results.
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EXECUTIVE SUMMARY

The Economic Impact of Public Infrastructure in Ontario

At a Glance

- Research has found a strong correlation between the physical stock of public capital and an economy’s overall productivity.
- Public capital has been a strong contributor to the performance of Ontario’s private sector over the past 30 years.
- Each dollar of real public infrastructure spending through ReNew Ontario is adding $1.11 to Ontario’s real gross domestic product.
- If not for recent increases in infrastructure spending, Ontario’s economy would have lost an additional 70,000 jobs in 2009.
- Government infrastructure spending in Ontario is estimated to have supported 182,897 jobs in 2009; this will rise to an estimated 223,268 jobs in 2010.

The Conference Board of Canada has been working with Infrastructure Ontario to assess the economic contribution of Ontario’s infrastructure investment program, ReNew Ontario, launched in 2005. First, we reviewed existing literature to summarize the methods for assessing the impact that public infrastructure has on the economy. Relying on empirical methods found in the literature, we then quantified the impact that infrastructure capital had on Ontario’s productivity and economic growth between 1980 and 2008. Finally, we conducted an economic impact analysis to examine, more specifically, the impact that infrastructure investment is having on employment and output associated with the construction phase of the ReNew Ontario program.

To put this research in context, we can rely on an earlier framework developed by the Conference Board that suggests that long-term economic growth and prosperity for any society can, in large part, be attributed to the quantity and quality of its capital. This capital comes in four major forms: natural capital (resources such as forests and water); human capital (relating to the quantity and quality of the labour force); organizational capital (governance and regulatory system); and physical capital. Physical capital includes both public and private infrastructure.

Although quantifying the contribution of public infrastructure to gross domestic product growth is challenging, and therefore has often been overlooked, a key objective of this research is to help eliminate this shortcoming and examine the contribution to economic growth made by infrastructure spending. Indeed, our findings reveal that, over recent history, public infrastructure has helped lift
economic growth by increasing the productivity of Ontario’s economy. Moreover, previous studies reveal various channels through which this can occur. Roads and public transportation, for example, can reduce business costs and improve competitiveness.

THE LINK BETWEEN PUBLIC INFRASTRUCTURE AND PRODUCTIVITY

In examining economic data for Canada, the United States, and other developed economies, researchers have found a strong correlation between the physical stock of public capital and an economy’s overall labour productivity performance. Productivity is the amount of output produced for each hour of work, and is therefore a measure of how efficiently goods and services are produced. Because productivity is an important contributor to long-term output, prosperity, and competitiveness, the body of research examining this issue has grown significantly. Methodologies for measuring the link between public infrastructure and production have evolved over several decades.

Findings that public infrastructure contributed to private sector output and productivity came with some criticism. One of the early quantitative methods used to evaluate the strength of the relationship between public infrastructure and productivity is the production function approach, which suggests that an economy’s output of goods and services is a function of labour and capital. A third factor, total factor productivity (TFP), determines the efficiency with which labour and capital mix to produce output. David Aschauer was one of the first to argue that an economy-wide production function should be expanded to include public as well as private capital.1 Using U.S. data, he found a high correlation between the productivity slowdown in the 1970s and 1980s and the slowdown in public infrastructure investment.

Following Aschauer’s methodology, Alicia Munnell concluded that investment in highways and in water and sewer systems had strong impacts on private production, while investment in schools and hospitals did not.2 Using a similar approach, Peter Wylie found that a 1 per cent increase in public infrastructure investment could lift private output by as much as 0.4 per cent in Canada.3 A series of studies also relied on the production function approach to find that significant savings were passed on to the private sector as a result of the completion of the interstate highway system in the U.S. in the early 1970s.4

Findings that public infrastructure contributed to private sector output and productivity did not come without criticism. John Tatom pointed out that although productivity growth and public infrastructure follow similar patterns over history, this does not necessarily imply that one causes the other.5 He argued that the cause and effect could be reversed; for instance, that large productivity gains could lead the now-richer voters to demand more public capital.

The critique that production function analysis inflated the impact of investment in public capital infrastructure led researchers to explore the use of cost functions. Cost functions—which include input prices for labour, materials, and private capital—provide a way to calculate the savings for private production realized by one additional unit of public infrastructure investment. Unlike production functions, cost functions account for the decision-making process that businesses use when selecting inputs for production. By estimating cost functions for Canada, Tarek Harchaoui and Faouzi Tarkhani found that a $1.00 increase in the net public infrastructure capital stock led to around 17 cents worth of savings for the private sector.6

1 Aschauer, “Is Public Expenditure Productive?”
2 Munnell, “How Does Public Infrastructure Affect Economic Performance?”
3 Wylie, “Infrastructure.”
5 Tatom, “Paved With Good Intentions.”
6 Harchaoui and Tarkhani, “Public Capital.”
Ryan Macdonald used both the production function and cost function approaches to “triangulate” an estimate of the use of public capital by private businesses in Canada. He and Wulong Gu found that public infrastructure spending accounted for roughly 50 per cent of the growth in TFP in Canada between 1962 and 2006.

**LONG-TERM BENEFITS OF ONTARIO’S INFRASTRUCTURE SPENDING**

The observation that infrastructure investment was vigorous during the 1960s and 1970s also applies to Ontario, especially during the 1960s when the Trans-Canada Highway and other large-scale public works such as Toronto’s subway system were being built. With the completion of these megaprojects, growth in public capital stock began to slow in the 1970s and continued at a slower pace through to the 1990s. Business capital stock grew faster than public stock in the 1970s, 1980s, and 1990s (although at a declining rate). However, over the past decade (to 2008), programs such as ReNew Ontario—which is aimed at education and health-care infrastructure—and Move Ontario—which is aimed at increasing public transportation capital—have helped growth in public investment to overtake gains in private capital once again.

**The public capital contribution to labour productivity has been relatively constant over the past 30 years.**

We used the approach taken by Gu and Macdonald to examine whether investments in public infrastructure have helped lift private sector productivity, output, and competitiveness. Data limitations prevent the analysis from extending back to the 1960s, when public capital was robust and the strongest links between public infrastructure and private productivity were typically established. Still, with our analysis reaching back to the 1980s, we find that public capital has been a strong contributor to the private sector performance in Ontario.

The public capital contribution to labour productivity has been relatively constant over the past 30 years, averaging 0.2 per cent per year in each decade because of gains brought about by an increased stock of public capital. But public capital made a larger impact on labour productivity in the 2000s than in other decades, accounting for a quarter of labour productivity growth in the 2000s, compared with only 8 per cent in the 1990s. Government investment required a boost for maintenance and improvements that were often deferred in the 1990s. Indeed, analysts describe much of the infrastructure spending of the 1990s as “patching holes” instead of adding to the stock of infrastructure. Public infrastructure programs such as Move Ontario and ReNew Ontario contributed to public capital’s larger share of labour productivity in the 2000s. From 1980 to 2008, public capital accounted for 12 per cent of labour productivity gains in Ontario.

**INFRASTRUCTURE SPENDING COUNTERING THE BUSINESS CYCLE**

In light of today’s steep global economic downturn, there has been strong consensus that governments need to act quickly to stimulate the economy and dampen the socio-economic costs of a decline in real GDP and employment. Moreover, the call for public intervention has gone beyond the usual social safety net to include heavy doses of monetary and fiscal stimulus. In addition to the ReNew Ontario program, Ontario’s March 2009 budget was aimed at taking advantage of the federal government’s infrastructure stimulus plan. According to the Ministry of Energy and Infrastructure, the province’s total infrastructure budget will be more than doubled over the next two fiscal years, compared with investment in 2008–09. The increased spending will provide a strong economic stimulus to the economy. Indeed, infrastructure spending builds assets whose economic useful life will extend far beyond the recovery. We used the Conference Board’s economic model of the Ontario economy to quantify the impacts associated with increased economic activity—related only to the construction phase of the program.

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7 Macdonald, “An Examination of Public Capital’s Role.”
8 Gu and Macdonald, “The Impact of Public Infrastructure.”
9 See Bishop and Burleton, A New Normal for a description of infrastructure spending and productivity growth in Canada.
In real terms, the cumulative $53.6 billion in public infrastructure spending generates a total of $59.3 billion in real GDP from 2006 to 2010. In other words, each dollar of real public infrastructure spending generates $1.11 in real GDP. Over the same period, a total of 822,335 person-years of employment are created in the province, with annual job creation expected to peak in 2010 with over 223,000 new jobs, when the unemployment rate edges down 1.3 percentage points. Just under half of the new jobs are estimated to be created in the services sector, while 33 per cent are in the construction industry. The manufacturing and the primary sectors generate roughly 12 per cent and 7 per cent (respectively) of the new jobs. Capital investment spending from the ReNew Ontario program is also estimated to lift personal income by a cumulative $48.7 billion from 2006 to 2010 and add $10.3 billion to corporate profits. Personal income and indirect tax collections are lifted by a cumulative $12.4 billion: 43 per cent accrued to federal coffers, 23 per cent to the province, and the remainder due to a lift in indirect taxes collected by both levels of government.

**The manufacturing and primary sectors generate roughly 12 per cent and 7 per cent (respectively) of new jobs.**

The impact that the additional boost to infrastructure spending—partly due to the new short-term initiatives to counter the recession—has in 2009 and a further 0.4 percentage points in 2010. The boost to employment is similarly impressive. If not for the stimulative impact of the increase in public investment, Ontario’s economy would have lost an additional 70,000 jobs in 2009. In 2010, when infrastructure spending peaks, another 40,000 jobs will be added to the payrolls in the province.

**ALTERNATIVE ECONOMIC EFFECTS FROM PUBLIC INFRASTRUCTURE**

Infrastructure construction spending is useful in countering the business cycle over the short term, and the completed infrastructure projects can lead to productivity gains over the medium term and even the long term. The literature contains numerous studies looking at links between transportation and the value of time, labour market issues, costs imposed by congestion, pollution, and global warming. The effect of transportation on urban issues such as agglomeration—the clustering of firms in an urban area—has generated a great deal of interest in the media. Moreover, investment in health care and education carry innumerable long-term benefits in terms of improved health and educational attainment. Other studies point to possible downsides to infrastructure spending—for example, that increased roads and highways can lead to urban sprawl, increased air pollution, and more greenhouse gas emissions. Clearly, there is a high degree of interdependence between the quality and quantity of public infrastructure, the performance of a society’s business sector and, ultimately, the quality of life of its citizens.
CHAPTER 1

Introduction

Chapter Summary

- This report assesses the economic contribution of Ontario’s infrastructure investment program, ReNew Ontario, launched in 2005.
- Public infrastructure has had a significant impact in lifting economic growth over the past 30 years by increasing the productivity of Ontario’s economy.
- The key to long-term economic growth and prosperity for any society can, in large part, be attributed to its capital—natural capital (resources such as forests and water), human capital (relating to the quantity and quality of the labour force), organizational capital (governance and regulatory system), and physical capital (public and private infrastructure).
- There is a high degree of interdependence between the quality and quantity of public infrastructure, the performance of a society’s business sector and, ultimately, the quality of life of its citizens.

To put this research in context, we rely on an earlier framework developed by the Conference Board that suggests the key to long-term economic growth and prosperity for any society can, in large part, be attributed to the quantity and quality of its capital. This capital comes in four major forms: natural capital (resources such as forests and water), human capital (relating to the quantity and quality of the labour force), organizational capital (governance and regulatory system), and physical capital. Physical capital includes both public and private infrastructure.

Although quantifying the contribution of public infrastructure to gross domestic product growth is challenging, and therefore has often been overlooked, a key objective of this research is to help eliminate this shortcoming and examine the contribution to economic

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growth made by infrastructure spending. Indeed, our findings reveal that public infrastructure has had a significant impact in lifting economic growth over the past 30 years by increasing the productivity of Ontario’s economy. Moreover, previous studies reveal various channels through which this can occur. As an example, one can easily understand how efficient public transportation can reduce business costs and improve competitiveness. Reviewing the existing literature leads to the conclusion that there is a high degree of interdependence between the quality and quantity of public infrastructure, the performance of a society’s business sector and, ultimately, the quality of life of its citizens.

This report begins with a survey of the literature on how the contribution of public infrastructure affects productivity and output in developed countries. Then, the methods in the literature are used to quantify the effects of public infrastructure in Ontario over the past 30 years. An economic impact assessment is conducted in Chapter 4 to measure the overall effects of the ReNew Ontario initiative on employment, income, housing, and other economic indicators. In Chapter 5, we examine the literature for other benefits and consequences of public infrastructure. We conclude the report with a summary of the findings.
CHAPTER 2

The Link Between Public Infrastructure and Productivity

Chapter Summary

- Researchers have found a strong correlation between the physical stock of public capital and an economy's overall productivity.
- Studies in the 1990s used the production function approach to quantify the relationship between public infrastructure and productivity.
- Recent studies have used cost functions to calculate the savings for private production realized by each additional unit of public infrastructure investment.
- Statistics Canada research has found that public infrastructure spending accounted for roughly 50 per cent of Canada's growth in total factor productivity between 1962 and 2006.

The view that public infrastructure has an important impact on the economy has been closely examined by economists for a number of decades. The original research was qualitative and anecdotal in nature. In the 1980s, the research became more quantitative as economists used production and cost functions to estimate the impact that public capital investment had on the U.S. economy. More recently, new growth theory and general equilibrium models have been used to examine this issue.

In addition to the relationship between public infrastructure and the macroeconomy, the literature also contains numerous studies of links between transportation and the value of time, labour market issues, costs imposed by congestion, pollution, and global warming. Also, the effect of transportation on urban issues such as agglomeration has generated a great deal of interest in the media. This review looks at some of these issues in addition to the macroeconomic impacts.

PRODUCTION FUNCTION APPROACH

In its simplest form, the production function approach suggests that production (or output) is a function of inputs that include labour, the stock of capital, and total factor productivity (TFP). While the relationship is intuitive at the firm level, it becomes less clear when looking at the broader economy. Moreover, production

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2 Agglomeration refers to the clustering of firms in an urban area. Interactions between firms and workers enable the sharing of knowledge and the development of new ideas. Agglomeration also provides workers with a greater choice of jobs, and firms have access to a larger pool of potential workers. These developments result in productivity improvements.

3 Total factor productivity measures the efficiency gains from all factors of production. TFP is typically estimated by the portion of real GDP growth that is not explained by gains in measurable factors of production such as labour and capital. Thus, estimates of TFP can vary, depending on the factor inputs used and the specification of the production function. TFP is different from the simpler measure defined as labour productivity, which is a calculation of production per hour worked. Labour productivity benefits from gains in TFP as well as growth in the amount of capital per worker.

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1 Gillen, "Public Capital."
functions can get complicated if one wishes to split the stock of capital into its many subcomponents. For example, the capital stock could include natural capital such as oil fields or trees. Another split that has been of interest recently is between buildings and other structures and information communications and technology (ICT) to examine how the adoption of computers has affected output; other analysis has focused on splitting out non-ICT machinery and equipment investment.

Recent research suggests a robust causal relationship between investment in public capital and private output.

For our purposes, we reviewed literature that instead examined how public capital might affect output using the production function approach. In principle, separating public from private capital in the production function should allow researchers to estimate the impact that public capital has on output. Moreover, the production function can often be rearranged to examine the impact that public capital has on business productivity. While the theory is simple enough, examining the issue statistically can result in a wide range of impacts and conclusions. Nonetheless, more recent research, which overcomes earlier difficulties and critiques, suggests there is a robust causal relationship between investment in public capital and private output.

David Aschauer was among the first to use a production function approach to examine the link between investment in public infrastructure and output and production. He argued that public infrastructure should be considered as another factor input in the production function, similar to private sector inputs. Aschauer’s production function approach found a high correlation between low U.S. productivity growth in the 1970s and 1980s and a slowdown in public infrastructure investment. His analysis consisted of a Cobb-Douglas production function that assumed constant returns to scale. Aschauer split apart the capital stock component into private capital and non-military government capital. The simple form of his production function was:

\[
Y = A^*(K, N, I)
\]

where
Y = real output of goods and services in the private sector
A = measure of technical change
K = aggregate stock of non-residential capital
N = aggregate employment of labour services
I = stock of public capital

His empirical analysis of 1949 to 1985 concluded:

- The net public capital stock played an important role in explaining the productivity slowdown in the 1970s.
- Public infrastructure had a more important role in explaining changes in productivity than private capital investment.
- A 1 per cent increase in public capital resulted in an increase in productivity ranging from 0.38 to 0.56 per cent.

Aschauer also examined the relationship between public capital investment and productivity in the G7 countries. He found that productivity growth in the 1970s and 1980s in all G7 countries was half of what it was in the 1960s. At the same time, five of the seven G7 countries (the United States, Canada, West Germany, France, and the United Kingdom) experienced a decline in the ratio of public investment to GDP. Aschauer concluded that the general shift in budget priorities away from capital accumulation toward consumption may partially explain the decline in productivity growth.

In the 1990s, Aschauer modified his original work to examine what the optimum public capital stock should be in the United States. He defined the optimum as the ratio of public capital to private capital that generates maximum GDP growth. Aschauer concluded that the optimum public capital to private capital stock ratio should be around 61 per cent. Public investments that

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4 Aschauer, “Is Public Expenditure Productive?”
5 The Cobb-Douglas production function is one among many different types of functional forms often used by economists. In particular, the Cobb-Douglas form imposes strict restrictions such that the function is homogeneous of degree one, and has a unitary elasticity of substitution.

6 Aschauer, “Public Investment.”
7 Aschauer, How Big Should the Public Capital Stock Be?
generate a ratio of public capital stock to private capital stock below this range result in an underperforming economy. From 1970 to 1990, the average public capital to private capital stock ratio was 44.6 per cent, 26 per centage points below the optimum level of 61 per cent.

Alicia Munnell’s work built on the research carried out by Aschauer. Her empirical results were also derived from a production function that included public capital as a separate variable. Munnell’s research differed slightly from Aschauer’s in that she used empirical methods to estimate productivity equations. She concluded that the public capital–labour ratio dropped by an annual average rate of 0.5 per cent from 1973 to 1979. The ratio continued to fall by 0.4 per cent annually during 1979 to 1987. According to Munnell, the decline in this ratio was the primary factor behind the slump in labour productivity that occurred during the 1970s and 1980s. She concluded that labour productivity growth would have increased by an additional 1.7 per cent annually if the public capital–labour ratio had increased by 1 percentage point annually from 1973 to 1987. Investing in public capital to ensure that the public capital–labour ratio expanded at the same rate as that for private capital would have increased the annual growth in labour productivity by 2.1 per cent.

Munnell also used the standard production function analysis to look at the impact of public capital spending on productivity and economic activity at the state and local levels. This differed from the work by Aschauer that used national-level data on public infrastructure investment. Munnell found that state and local public capital had a statistically significant effect on output. The output elasticity for public capital was 0.15, suggesting that a 1 per cent increase in public capital would result in an increase in output of 0.15 per cent. Still, this elasticity estimate was lower than the 0.35 estimate found when national level data were used. In addition, Munnell found that the impact of public capital was roughly half that of private capital. She also examined the impact of different components of public capital on output. The major impact on output from capital spending came from highways and from water and sewer systems, whereas public capital spending on schools and hospitals did not seem to have a significant effect on private production.

Well-maintained roads reduce the wear and tear on commercial vehicles—improving efficiency in the private sector.

Peter Wylie used Aschauer’s methodology to examine the impact of public capital investment spending on the Canadian economy. Regression analysis revealed that the elasticity of business sector output with respect to public infrastructure investment was significant, with an elasticity estimate of 0.407. Similar to many of the American studies that analyzed data at the national level, Wylie found that the elasticity for public infrastructure investment was higher than that for private business investment. Wylie concluded that public infrastructure has played a key role in national economic growth and productivity.

Bilkis Khanam estimated the impact of highway infrastructure capital on output in the goods-producing sector of the Canadian economy using the production function methodology. Her results revealed that investment in highways had a significant impact on the goods-producing sector. Well-maintained roads reduced the wear and tear on commercial vehicles, thereby improving efficiency in the private sector.

James Brox noted that large infrastructure projects have always been at the centre of Canada’s economic development. Some of these key projects include the Canadian Pacific Railway, the Trans-Canada Highway and the TransCanada Pipeline. Brox noted that Canada now has an infrastructure gap that is having a negative effect.
on manufacturing costs and productivity. As a per cent of GDP, investment in public infrastructure has dropped to around 50 per cent of its 1960s levels, leaving many important public facilities in disrepair. The collapse of the Boulevard de la Concorde overpass in Montréal illustrates the extent of the problem that now exists in Canada. Brox estimated that an injection of $200 billion in spending on public infrastructure would be required over the next few years to eliminate the gap.

The decline in infrastructure spending in Canada has a direct impact on productivity in manufacturing.

Brox also argued that the decline in Canada’s public infrastructure stock has coincided with a reduction in productivity growth in Canada’s manufacturing sector compared with that of the United States. Productivity levels between the two countries were similar in the 1960s. But by 2006, productivity in Canada was 20 per cent lower than in the United States. The decline in infrastructure spending in Canada over the past few decades has a direct impact on productivity in manufacturing. (The U.S. did not experience the same decline in public infrastructure spending—see below.) For instance, firms need water, power, and transportation facilities to produce and transport their products. Poor infrastructure adds to the cost of doing business.

John Baldwin and Jay Dixon also looked at the differences in public infrastructure spending between Canada and the United States. They noted that spending on public infrastructure in Canada has gone through two distinct phases. From 1960 to 1980, spending growth was generally higher than in the United States. After 1980, public infrastructure spending growth was lower than in the United States. The weaker spending in Canada after 1980 was likely due to the economic cycle in Canada at the time. The resource economy that soared in the late 1970s was less vibrant after 1980 and infrastructure spending to support this industry slowed.

The original work by Aschauer also led a number of other researchers to investigate the impact of investment in U.S. interstate highways. Ishak Nadiri and Theofanis Mamuneas found that highway capital investment contributed to output growth, lower costs, and increases in profitability for the transport-using sector. They concluded that the output elasticity for highway capital averaged 0.08 between 1950 and 1991, although it dropped from 0.15 in 1950 to 0.03 in 1991.

Analysis of the productivity effects attributable to investment in highways was completed by T.E. Keeler and Chad Shirley. Keeler concluded that there was a significant impact on costs in the trucking industry as a result of investment in roads. Specifically, costs in the trucking industry were close to 20 per cent lower in 1973 than they would have been absent the post-1950 additions to the U.S. highway system. These savings turned out to cover 72 per cent of the capital costs involved with highway investment. Shirley concluded that savings on inventories due to quicker delivery on improved highways resulted in a rate of return on highway investments in the 1970s of close to 18 per cent. Rates of return from highway investment gradually declined through the 1980s and 1990s as the impact of trucking deregulation contributed more to trucking logistics than infrastructure improvements.

John Fernald found that industries that used road transport frequently had faster productivity growth (as measured by total factor productivity) between 1951 and 1973. His econometric research concluded that road construction contributed 1.4 percentage points to economy-wide TFP growth for that time period. Fernald also found that the TFP effect for highway construction started to fade after 1973. It seemed that there was a one-time effect of completing the interstate highway system in the early 1970s and that a continuation of the huge investment in road construction would not have led to faster TFP growth after 1973.

13 Baldwin and Dixon, Infrastructure Capital.
15 Keeler, “Measuring the Benefits.”
16 Shirley, “Firm Inventory Behavior.”
17 Fernald, “Roads to Prosperity?”

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It is also important to note that the gains from the original investment in highway construction were partially offset in later years by increases in congestion. Urban areas experienced a sharp rise in delays and journey times at peak hours between 1980 and 2000. For instance, Edward Glaeser and Janet Kohlhase concluded that average commute times increased by 13 per cent between 1980 and 2000.18

Critics of Aschauer’s work and others’ were sceptical of the results showing large rates of return resulting from investment in public infrastructure. Henry Aaron rejected the estimates of the productivity of public capital found in Aschauer’s work.19 He believed that Aschauer’s use of aggregate time series data led to difficulties because of the dominance of trend in the estimations. Another difficulty in production function analysis occurs because of the assumption of competitive factor markets. This becomes a problem when using public capital, which does not have a market price.

Edward Gramlich contended that it is difficult to make the link between the slowdown in productivity growth in the 1970s and 1980s and the decline in growth in public infrastructure investment.20 Although better highways could lower the cost of trucking and improve national output, Gramlich noted that many of the benefits of highway investment save time for private individuals. These savings would not be directly accounted for in national output. Also, the public capital stock that includes schools and hospitals, as well as their maintenance, should not have a significant impact on the supply of aggregate output. Gramlich concluded that only two-thirds of the public capital stock could raise national output. According to Gramlich, this made the high rates of return on public capital found by Aschauer even more implausible.

Gramlich was also critical of Aschauer’s findings that the rate of return on public capital is higher than the rate of return on private capital. The private capital rate of return reveals how investors make decisions at the margin: they compare the marginal output benefits of their capital with the opportunity cost of their own funds. Similarly, investors would compare the marginal output benefits of public capital with the opportunity costs of other investments. If public investment were as profitable as Aschauer contended, investors would demand that the public sector float bonds to build new roads and sewers in order to produce these high net benefits. Yet Gramlich noted that most of the complaints that investors had in the 1980s were not that public investment was too weak, but rather that tax rates were too high.

Between 1980 and 2000, urban areas experienced a sharp rise in peak-hour delays and journey times.

Gramlich also claimed that the econometric analysis done by Aschauer and others missed a crucial variable. Energy prices started to accelerate at the same time as the stock of public infrastructure and productivity growth started to decelerate. He felt that energy prices should have been controlled for in the aggregate production function.

Glenn Otto and Graham Voss looked at the provision of public capital in Australia over three decades.21 Similar to Gramlich, the authors were sceptical of the high returns to investment in public infrastructure found by Aschauer and others and could find little evidence of this development in Australia. They concluded that the declining growth in public capital was a result of the rising cost of public investment. At the same time, private investment goods became relatively less expensive and, consequently, private capital intensity increased more than public capital intensity. The increase in the cost of public infrastructure could be linked to tighter regulations on, for instance, specifications for new roads and highways as well as more stringent environmental assessments.

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18 Glaeser and Kohlhase, Cities, Regions.
19 Aaron, “Discussion.”
20 Gramlich, “Infrastructure Investment.”
21 Otto and Voss, “Is Public Capital Provision Efficient?”
John Tatam was also critical of the view that the decline in the public capital stock in the 1970s was responsible for the productivity slowdown and the resulting decline in the U.S. standard of living.22 Tatam noted that, while public capital formation slowed down considerably in the 1970s, the decline centred on highways and streets, and educational buildings. These two categories of public infrastructure were hurt by changes in demographics and energy prices, which lowered the demand for these two goods.

Tatam argued that the empirical work indicating that the public capital stock has a significant impact on private sector output is seriously flawed. The flaw is referred to as “spurious regression.” Simply because productivity growth and public capital spending declined at the same time over history does not necessarily imply that the decline in public capital spending caused the decline in productivity. The cause and effect could be reversed. Tatam noted that countries with high income and productivity have, in fact, more public capital per worker. However, this does not necessarily imply that public infrastructure increases private sector productivity. It could be that high-income voters demand more of all types of goods and services, including the services from public infrastructure. In other words, changes in productivity and income cause public infrastructure to adjust, not the other way around. When these statistical flaws were corrected using a Granger causality test, Tatam found no evidence that an increase in the public capital stock led to a rise in private sector productivity.

In response to the criticism of the original production function analysis, economists tried different approaches to re-examine the issue. Sau-Him Paul Lau and Chor-Liu Sin built on the methodology used by Aschauer and others to look at the impact of public infrastructure spending on productivity in the U.S. economy.23 The authors noted that the earlier work that used single equation regressions on aggregate time series data for the production function was criticized because the variables from the regression could be jointly endogenous. As a result, reverse causality could be present. To avoid this problem, the authors used analysis of variance techniques on a system comprising per capita output, private and public infrastructure, and a linear time trend. They applied a multivariate stochastic cointegration test on U.S. data between 1925 and 1989. The authors found that the elasticity of output for public capital was 0.11. This result was significantly less than the elasticities derived from Aschauer’s work.

Simply because productivity growth and public capital spending declined at the same time over history does not necessarily imply that the decline in public capital spending caused the decline in productivity.

As mentioned, Munnell analyzed the impact of public infrastructure on the U.S. economy at the state and county level.24 The results indicated that the effect of investment in public infrastructure on the local economy is much weaker than at the national level and that the composition of public infrastructure assets is important—that is, investment in highways and in water and sewer systems boosts private sector output much more than investment in schools and hospitals. Also arguing against a large impact of public infrastructure in investment on the economy, Amitabh Chandra and Eric Thompson found that public infrastructure investment at the county level leads to a redistribution of economic activity as opposed to an actual net gain in output.25 After analyzing data on interstate highway construction and economic activity at the county level in the United States from 1969 to 1993, they concluded that spending on highways increased economic growth in the counties that the new roads went through. However, the higher growth was offset by a decline in growth in the counties that were bypassed by the new roads.

22 Tatam, “Paved With Good Intentions.”
23 Lau and Sin, “Public Infrastructure and Economic Growth.”
24 Munnell, “How Does Public Infrastructure Affect Regional Economic Performance?”
COST FUNCTION APPROACH

The critique that production function analysis inflated the impact of investment in public capital infrastructure led researchers to explore the use of cost functions. Cost functions—which include input prices for labour, materials, and private capital—provide a way to calculate the savings for private production realized by one additional unit of public infrastructure investment. Unlike production functions, cost functions account for the decision-making process that businesses use when selecting inputs for production.

Cost functions are generally structured as follows:

\[ C = f(X, KI, Q, T) \]

... where:

- \( C \) = private production cost
- \( X \) = output
- \( KI \) = flow of services from the public capital stock
- \( Q \) = the vector of input prices for labour, private capital and material
- \( T \) = technical change

This function implies, for instance, that a better highway system reduces costs for the private sector as a result of less driving time, lower demand for fuel, and lower labour costs. Similarly, a more up-to-date telecommunication system lowers the communication costs for business.\(^{26}\) Aggregate production functions such as those used by Aschauer do not account for the decision-making process that businesses use when selecting the inputs for production.

Klaus Conrad and Helmut Seitz used cost functions for the German economy to conclude that increases in public infrastructure investment are a significant factor in reducing costs in the German manufacturing, trade, transport, and construction sectors of the economy.\(^{27}\)

Tarek Harchaoui and Faouzi Tarkhani’s research using cost functions for Canada revealed that the average marginal benefit for private sector production associated with public infrastructure capital was 0.17 between 1961 and 2000.\(^{28}\) This means that a $1.00 increase in the net public infrastructure capital stock led to around 17 cents worth of savings for the private sector. The savings were the greatest for capital-intensive industries such as transportation.

Cost functions account for the decision-making process that businesses use when selecting inputs for production.

GROWTH ACCOUNTING METHODOLOGY

Some analysts have used a growth accounting framework to examine the impact of public infrastructure investment on the economy. The traditional growth accounting framework breaks down changes in GDP into portions that are attributable to changes in labour, changes in capital, and the residual referred to as TFP. Wulong Gu and Ryan Macdonald used this approach to analyze the impact of public infrastructure spending on productivity in Canada.\(^{29}\) To examine the impact of public capital, changes in TFP were split into the contribution from public capital and from technology.\(^{30}\)

Given that public capital does not have a market price, it isn’t possible to use non-parametric estimates for its elasticity in a production function. Consequently, Gu and Macdonald used elasticity estimates from Macdonald’s earlier work based on both the production function and cost function approaches discussed above.\(^{31}\)

27 Ibid.
28 Harchaoui and Tarkhani, “Public Capital and Its Contribution.”
29 Gu and Macdonald, “The Impact of Public Infrastructure.”
30 This approach assumed constant returns to scale across private inputs and that private factors are paid their marginal revenue product.
31 Macdonald, “An Examination of Public Capital’s Role.”
Using production function and cost function estimates, Macdonald calculated the elasticity of public capital that is not only consistent across the different methodologies but also overcomes various estimation problems. He found an elasticity estimate of 0.1 for the effect of public infrastructure spending on economic output. To account for the variability of elasticity estimates in the available research, he used a range of elasticity estimates of 0.05, 0.1, and 0.15.

After splitting the effect of public capital on TFP and using Macdonald’s earlier estimates of elasticity of public capital, Gu and Macdonald concluded that public infrastructure spending accounted for around 50 per cent of the TFP growth in Canada between 1962 and 2006. The largest impact of public infrastructure investment on labour productivity over the 47-year period was during the 1960s and 1970s. In subsequent decades, the contribution of public capital to labour productivity was around two-thirds lower than in the earlier period.

Economists using traditional multifactor productivity estimates have found it difficult to explain the slowdown in productivity growth that took place after 1980. The research by Gu and Macdonald, which accounted for the effect of public infrastructure spending in determining productivity trends, significantly reduced the overall productivity differences between the two periods. This suggested that part of the higher productivity growth before 1980 was a result of the sharp growth in spending on public infrastructure during this period. After 1980, when spending on public infrastructure slowed down, the overall trend in productivity growth in Canada declined.

Matilde Mas also used the growth accounting approach to examine productivity growth in Spain’s economy. During 1995 to 2000, labour productivity growth was negative (~0.08), before recovering slightly in 2000 to 2004 with an average growth of 0.62 per cent per year. Two factors were responsible for the negative rate of change in labour productivity in the second half of the 1990s: a deceleration in capital endowments per worker and a negative contribution in TFP growth. During this period, the contribution of infrastructure spending to productivity growth in the Spanish economy was negative. However, the contribution to productivity growth from infrastructure spending was positive from 2000 to 2004, averaging 0.13 per cent per year.

**NEW GROWTH THEORIES AND GENERAL EQUILIBRIUM MODELS**

The analytical framework for the production and cost function approaches was built on the neoclassical economics framework, which assumes that technology is exogenous and factor inputs are paid based on their worth or marginal products. Government policies can have a short-run effect on real growth but, in the long run, real incomes can only expand if labour productivity improves. In new growth models, technology is endogenous. In other words, in the long run, technology and productivity can be determined by, among other factors, the level of government spending.

In the 1990s, new growth theories, developed by the influential economist Robert Lucas, began with the assumption that productivity growth in the economy was endogenous and depended on the presence of factors such as education, R&D investment, the savings rate, and public infrastructure investment. Results from his work revealed that, if the level of public capital in the economy was low compared with the level of private capital, the gains for the economy from shifting resources toward public capital could be significant.

New-growth-theory economists also built models that identified the factors that determined long-run growth in total factor productivity in different countries. Regressions were estimated with the growth rates of individual

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32 Gu and Macdonald, “The Impact of Public Infrastructure.”
33 Mas, “Infrastructures and New Technologies.”
34 Gillen, “Public Capital, Productivity.”
35 Ibid.
countries on the left-hand side and a number of different variables such as the share of investment in GDP on the right-hand side. Results from these growth-regression models were mixed in terms of the impact that public infrastructure investment had on economic growth. William Easterly and Sergio Rebelo found that the share of public investment in transportation and communications was strongly correlated with economic growth for a number of developed and developing countries.\(^\text{36}\) Conversely, Robert Barro found that there was little relationship between economic growth and the quantity of public capital.\(^\text{37}\) Barro’s analysis considered 98 countries between 1960 and 1985.

Dynamic general equilibrium models have also been used to examine the impact of infrastructure investment on the economy. In these models, the long-run effects of public infrastructure investment on the economy are considered in an environment where changes in public capital investment affect real interest rates, labour supply, and consumption. General equilibrium models also allow for substitution among the various factors of production as their relative prices change. Marianne Baxter and Robert King concluded that the impact of public infrastructure investment on the economy—derived using general equilibrium models—tends to be smaller than and differs significantly from the results obtained from static models.\(^\text{38}\)


CHAPTER 3

Long-Term Benefits of Ontario’s Infrastructure Spending

Chapter Summary

- The contribution of public capital to private sector productivity is quantified by splitting public capital out from total factor productivity—which accounts for technological change, change in corporate structure, or benefits derived from research and development spending and patents.
- Total factor productivity has been the largest contributor to labour productivity.
- Growth in public capital stock in Ontario boosted business sector productivity by 0.2 per cent over 1980 to 2008, accounting for almost an eighth of the growth in productivity.
- Programs such as ReNew Ontario, aimed at increasing education and health-care infrastructure, and Move Ontario, aimed at increasing public transportation capital, have helped growth in public investment to overtake gains in private capital.

In this section, we use the approach taken by Gu and Macdonald to examine whether investments in public infrastructure have helped lift private sector productivity, output, and competitiveness in Ontario. The contribution can be quantified by splitting out public capital from total factor productivity estimates. The analysis allows us to account fully for the contribution of public infrastructure to labour productivity and GDP growth.

Infrastructure investment was vigorous over the 1960s and 1970s in Ontario. This is especially true during the 1960s, when the Trans-Canada Highway and other large-scale public works such as Toronto’s subway system were being built. Over this decade, growth in public capital investment dominated private investment. (See Chart 1.) With the completion of these megaprojects, growth in public capital stock began to slow in the 1970s and continued at a slower pace through to the 1990s. This may be because more infrastructure was

Chart 1

Growth in Public and Business Real Capital Stock in Ontario (average logarithmic difference of the capital stock; per cent)

Source: Statistics Canada; The Conference Board of Canada.

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1 Gu and Macdonald, “The Impact of Public Infrastructure.”
built than was required in the 1960s, with the expectation that it would be in place in future decades when the demand was there. Meanwhile, business capital stock grew faster than public stock in the 1970s, 1980s, and 1990s (although at a declining rate).

The accessibility of public capital allows businesses to take it as a given, allowing them to choose a mix of labour and capital that minimizes cost and maximizes profit.

The Auto Pact of 1965 between the U.S. and Canada established a conditional free trade zone for vehicles and parts. As a result, the Canadian auto industry increased production fourfold by the late 1980s. During the 1960s and 1970s, Toronto also began to take Montreal’s place as Canada’s financial hub, aided by a rapid increase in industrialization and a growing number of corporate headquarters in Toronto.

Over the past decade (to 2008), programs such as ReNew Ontario—which is aimed at increasing education and health care infrastructure—and Move Ontario—which is aimed at increasing public transportation capital—have helped growth in public investment to overtake gains in private capital once again.

GROWTH ACCOUNTING METHODOLOGY

Public capital includes schools, hospitals, roads, and other federal, provincial, and municipal government capital. While the benefits of these structures to the average citizen are apparent, public capital also helps businesses by providing an educated and healthy population and by reducing travel time, for example. Since public capital is accessible to everyone, businesses can take it as a given when making business decisions. They are then able to choose a mix of labour and capital (buildings, machinery, etc.) that minimizes costs and maximizes profit. However, public capital is often not included in typical business sector production models because it is difficult to quantify. This section of the report helps to overcome this shortcoming by measuring the productive contributions of public capital. In doing so, we quantify some of the potential benefits that public capital brings to private sector production.

We use the growth accounting approach used by Gu and Macdonald to examine the extent to which investments in public infrastructure have helped lift private sector productivity, output, and competitiveness in Ontario. Data limitations prevent the analysis from extending back to the 1960s, when public capital was most robust and the strongest links between public infrastructure and private productivity were typically established. Still, with our analysis reaching back to 1980, we find that public capital has been a strong contributor to the private sector performance in Ontario.

The contribution can be quantified by splitting public capital out from total factor productivity. Total factor productivity is essentially the motor of economic prosperity. Positive TFP growth contributes, one for one, to overall GDP growth and labour productivity. Moreover, it remains the key long-term driver of competitiveness and real per capita income. Public infrastructure also contributes to output and labour productivity by adding to the stock of capital per worker. Thus, using the production function framework and accounting for public infrastructure separately from the estimate of TFP, it is possible to account for the contribution of public infrastructure to labour productivity.

(1) First, the standard Cobb-Douglas production function is used:

$$\text{GDP}_t = (\text{TFP}_t) \times (L_t^{\beta_L}) \times (K_t^{\beta_K})$$

where GDP is total output generated in the business sector, TFP is total factor productivity, L and K are measures for labour composition and capital stock in the business sector. $\beta_L$ and $\beta_K$ represent the elasticities of labour and capital—in other words, the responsiveness of output to changes in labour or capital. The year is denoted by $t$.

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Footnote:

2 In 1965, 670,000 vehicles were produced; that number jumped to 2.9 million by 1988, according to “In Depth: Auto Industry, History in Canada,” CBC News Online, August 21, 2006. Also, Statistics Canada reports that real GDP (in 1992 $) for the motor vehicle industry was worth $846 million in 1964 and $4,879 million in 1989.
We first estimate the elasticity of labour ($\beta_l$) as the proportion of nominal labour income in the business sector out of total income in the business-sector economy. From there, we take the standard economic assumptions of competitive markets and constant returns to scale to generate ($\beta_l + \beta_k = 1$).

(2) Second, we take the logarithmic difference of (1) and get:

$$\Delta \ln(GDP_t) = \Delta \ln(TFP_t) + \beta_l \Delta \ln(L_t) + \beta_k \Delta \ln(K_t)$$

Total factor productivity is the only unknown variable in the equation, so it is calculated as the residual when all other changes in GDP are accounted for by labour and capital.

(3) Third, to estimate the contribution to labour productivity, we subtract the change in hours worked from the change in GDP in equation (2) to get:

$$\Delta \ln\left(\frac{GDP_t}{HRS_t}\right) = \Delta \ln(TFP_t) + \beta_l \Delta \ln\left(\frac{L_t}{HRS_t}\right) + \beta_k \Delta \ln\left(\frac{K_t}{HRS_t}\right)$$

This equation shows the relationship between labour productivity in the business sector (on the left-hand side) and the components that contribute to this productivity (TFP, labour composition, and business sector capital).

(4) Note that public capital is not included in equation (3). Because TFP is calculated as a residual, public capital has been lumped in with it. Therefore we separate out public capital from TFP:

$$\Delta \ln(TFP_t) = \Delta \ln(TFP^*_t) + \beta_g \Delta \ln(G_t)$$

... where $G_t$ is the public capital stock and $\beta_g$ is the elasticity of public capital. $\text{TFP}^*$ is TFP excluding public capital stock. By estimating equation (4), we can account for public capital’s contribution to labour productivity in the business sector.

The unknown variable in equation (4) is the elasticity of public capital, $\beta_g$. Measuring this is a challenging exercise because we do not know the market price of public capital, and there are no close proxies where private companies have created public infrastructure in Ontario that would yield a market price. Macdonald points out that estimates of TFP and the elasticity of public capital are statistically very hard to disentangle in the traditional production function approach because both track trend GDP in a similar fashion. Therefore, most studies use a cost-function approach. Macdonald estimates $\beta_g$ for Canadian infrastructure to be around 0.1 and warns there is a considerable range around the estimate. We use his estimate for elasticity of public capital in this analysis.

**DATA**

All data are provided by Statistics Canada. Business output and labour income data are taken from Statistics Canada’s annual Provincial Economic Accounts publication and expressed in real 2002 dollars in basic prices. The Labour Force Survey, conducted monthly by Statistics Canada, provides employment data for Ontario used in this study. Statistics Canada compiles estimates of real (inflation-adjusted) capital stock with information it collects from business and government entities. The data on hours worked and the average wage rate is collected from Statistics Canada’s Survey of Employment, Payroll and Hours database.

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3 Macdonald, “An Examination of Public Capital’s Role.”

4 Ibid., and Harchaoui and Tarkhani, “Public Capital and Its Contribution.”

5 Macdonald’s 2008 paper includes all investments made by the public administration sector, defined as the North American Industry Classification System (NAICS) 91 industry in his definition of public capital. This Conference Board report uses a broader definition that includes schools and hospitals.

6 The stock of capital rises with new investment net of depreciation, but various forms of depreciation can be applied to determine the value of the private and public capital stocks. In our work, we have opted for the approach that Statistics Canada defines as hyperbolic depreciation, a methodology that we feel best reflects the productive capacity of the assets.
The average number of hours worked in the Ontario economy has fluctuated significantly over history—much more than output has. The recessions in the early 1980s and 1990s took their toll on workers and resulted in large declines in hours worked. (See Chart 2.) Therefore, labour productivity—defined as total output per hour worked—has fluctuated considerably over time.

**FINDINGS**

The results from equations (3) and (4) appear in Table 1. Labour productivity has grown at a moderate pace over the past 30 years, although it grew the fastest in the 1990s. Several factors led to this boost in productivity growth. First, the recession at the beginning of the decade resulted in a steep decline in hours worked. Second, although hours were regained during the subsequent economic recovery, the second half of the decade also led to large investments in the information communications and technology sector. Another contributor to the rise in productivity was the signing of the North American Free Trade Agreement. NAFTA enabled Canadian businesses to improve their production technologies by purchasing machinery and equipment from American suppliers.

The contributions from business capital outstripped the contributions from labour composition from 1980 to 2008. Labour composition is calculated by weighing the hours worked with the wage share for each industry. Therefore, the drop in labour composition in the most recent decade represents a shift from higher-wage manufacturing jobs to lower-wage, service-oriented jobs. (See Chart 3.) This has had a negative effect on labour productivity, pulling it down 0.13 per cent from 2000 to 2008. Overall, over the past 30 years, labour composition has had a negligible impact on labour productivity.

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7 Hours worked is calculated here as a weighted average based on employment by industry.

8 A previous study done by The Conference Board of Canada, *IT and the New Economy*, found that investment in information technology made large contributions to labour productivity and overall output growth in the 1990s—much higher than IT’s share of the level of investment of total capital.

9 The construction of this variable follows that of Gu, “The Changing Composition of the Canadian Workplace and Its Impact on Productivity Growth.”
Total factor productivity has been the largest contributor to labour productivity, helping to boost growth in labour productivity by an average of 1.1 per cent per year.\textsuperscript{10} Generally, TFP is interpreted as technological change, and indeed technology has experienced rapid growth over the past 30 years. Another interpretation of TFP growth in the literature is change in corporate structure; TFP also includes benefits derived from research and development spending and patents, and everything else that is not accounted for in the capital or labour categories.

Public capital had a larger impact on labour productivity in the 2000s than in other decades.

The public capital contribution to labour productivity has been relatively constant over the past 30 years, averaging 0.2 per cent per year. But public capital had a larger impact on labour productivity in the 2000s than in other decades: it accounted for 24 per cent of labour productivity growth in the 2000s, compared with only 8 per cent in the 1990s, when budget balancing resulted in fewer funds for infrastructure. While public infrastructure programs such as Move Ontario and ReNew Ontario contributed to this larger share, so did the significant decline in the contributions from business capital and labour intensity. The decline in business capital formation coincided with a general decline in labour productivity growth; meanwhile, the contribution from public capital slightly increased, making public capital’s share of the contribution larger. (See Chart 4.)

In comparison with the numerous studies reviewed, our results suggest that growth in public capital stock in Ontario has generally contributed significantly to business sector productivity. Gu and Macdonald found that public stock accounted for about 9.5 per cent of growth in labour productivity in all of Canada from 1961 to 2006,\textsuperscript{11} compared with our finding of 12 per cent in Ontario from 1980 to 2008.

\textsuperscript{10} Our estimates for Ontario’s TFP growth over the past 30 years are in line with other estimates, including those from the Centre for the Study of Living Standards. See Sharpe and Arsenault, \textit{New Estimates}.

\textsuperscript{11} Gu and Macdonald, “The Impact of Public Infrastructure.”
Infrastructure Spending
Countering the Business Cycle

Chapter Summary

- Infrastructure investment data were used to “shock” the Conference Board’s provincial economic model of Ontario—that is, to show the effect the infrastructure spending has had on Ontario’s economy.

- Each dollar of real public infrastructure spending through ReNew Ontario is adding $1.11 to Ontario’s real gross domestic product, as well as helping to create jobs, boost personal incomes and corporate profits, and increase tax collections.

- The extra boost to infrastructure spending, partly due to new short-term initiatives to counter the recession, helped lift real GDP growth by 0.9 percentage points in 2009 and is forecast to add a further 0.4 percentage points in 2010.

- If not for the stimulative impact of this added boost to infrastructure spending, Ontario’s economy would have lost an additional 70,000 jobs in 2009. In 2010, when infrastructure spending peaks, another 40,000 jobs will be added to the payrolls in the province.

In light of today’s steep global economic downturn, there has been strong consensus that governments need to act quickly to stimulate the economy and dampen the socio-economic costs of a decline in real GDP and employment. Moreover, the call for public intervention has gone beyond the usual social safety net to include heavy doses of monetary and fiscal stimulus. In addition to the ReNew Ontario program, Ontario’s March 2009 budget was aimed at taking advantage of the federal government’s infrastructure stimulus plan. While the details of new infrastructure projects were not revealed in the budget document, the Ontario government mobilized about $3.4 billion per year for each of the following two fiscal years to help fight the recession.

According to the Ministry of Energy and Infrastructure, the province’s total infrastructure budget will more than double over the next two fiscal years, compared with investment in 2008–09. (See Table 2.) The increased spending will provide a strong economic stimulus to the economy. Indeed, infrastructure spending builds assets whose economic useful life will extend far beyond the recovery. However, we used the Conference Board’s economic model of the Ontario economy to quantify the impacts associated with increased economic activity, related only to the construction phase of the program.
Table 2
Ontario Infrastructure Spending
($ millions)

<table>
<thead>
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<tbody>
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<td>Transportation</td>
<td></td>
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<tr>
<td>Transit</td>
<td>1,541</td>
<td>1,624</td>
<td>1,858</td>
<td>1,251</td>
<td>1,687</td>
<td>1,506</td>
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<tr>
<td>Highway construction</td>
<td>1,237</td>
<td>1,426</td>
<td>1,452</td>
<td>1,484</td>
<td>1,718</td>
<td>2,034</td>
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<tr>
<td>Other transportation*</td>
<td>494</td>
<td>76</td>
<td>710</td>
<td>591</td>
<td>823</td>
<td>1,274</td>
</tr>
<tr>
<td>Total transportation</td>
<td>3,272</td>
<td>3,126</td>
<td>4,020</td>
<td>3,327</td>
<td>4,229</td>
<td>4,814</td>
</tr>
<tr>
<td>Health</td>
<td></td>
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<tr>
<td>Hospitals</td>
<td>296</td>
<td>375</td>
<td>638</td>
<td>1,048</td>
<td>2,543</td>
<td>3,438</td>
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<tr>
<td>Other health</td>
<td>166</td>
<td>183</td>
<td>286</td>
<td>248</td>
<td>635</td>
<td>474</td>
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<tr>
<td>Total health</td>
<td>462</td>
<td>558</td>
<td>924</td>
<td>1,296</td>
<td>3,177</td>
<td>3,912</td>
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<tr>
<td>Education</td>
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<td>School boards</td>
<td>949</td>
<td>1,000</td>
<td>950</td>
<td>1,019</td>
<td>1,504</td>
<td>1,608</td>
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<tr>
<td>Colleges</td>
<td>44</td>
<td>73</td>
<td>183</td>
<td>202</td>
<td>240</td>
<td>248</td>
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<td>Universities</td>
<td>88</td>
<td>52</td>
<td>678</td>
<td>55</td>
<td>106</td>
<td>73</td>
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<td>Total education</td>
<td>1,081</td>
<td>1,125</td>
<td>1,811</td>
<td>1,275</td>
<td>1,849</td>
<td>1,929</td>
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<td></td>
<td></td>
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<tr>
<td>Water/environment</td>
<td>342</td>
<td>360</td>
<td>388</td>
<td>303</td>
<td>259</td>
<td>274</td>
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<td>Municipal and local infrastructure</td>
<td>455</td>
<td>473</td>
<td>1,795</td>
<td>306</td>
<td>419</td>
<td>432</td>
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<tr>
<td>Justice</td>
<td>84</td>
<td>102</td>
<td>215</td>
<td>476</td>
<td>356</td>
<td>819</td>
</tr>
<tr>
<td>Total “other infrastructure”*</td>
<td>881</td>
<td>935</td>
<td>2,398</td>
<td>1,085</td>
<td>1,033</td>
<td>1,525</td>
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<tr>
<td>Total spending in all sectors</td>
<td>5,696</td>
<td>5,744</td>
<td>9,153</td>
<td>6,984</td>
<td>10,288</td>
<td>12,180</td>
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<td>Other plus estimate of partner funding**</td>
<td>760</td>
<td>1,108</td>
<td>1,165</td>
<td>878</td>
<td>2,235</td>
<td>2,964</td>
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<td>New short-term stimulus investments</td>
<td>3,431</td>
<td>3,450</td>
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<tr>
<td>Total gross infrastructure</td>
<td>6,456</td>
<td>6,852</td>
<td>10,318</td>
<td>7,862</td>
<td>15,954</td>
<td>18,594</td>
</tr>
</tbody>
</table>

*Includes Windsor Gateway.
**Based on loans data, total funding is 1.62 per cent of Infrastructure Ontario funding.
Sources: Ministry of Energy and Infrastructure; The Conference Board of Canada.

DATA

The Ministry of Energy and Infrastructure provided the Conference Board with public capital investment expenditures over the fiscal years running from 2005–06 to 2010–11. The data were converted to a calendar-year basis, allowing us to quantify the economic impact of infrastructure spending over the five years spanning from 2006 to 2010. Because there are large differences between the economic impacts obtained from labour-intensive construction and those obtained from machinery and equipment (M&E) investment (which often has high import content), it was necessary to break out the capital investment spending by type of asset. The Conference Board relied on historical data from Statistics Canada’s Private and Public Investment Intentions Survey to split the public capital investment data between construction (or what is termed “structures”) and M&E investment, depending on the broad sectors to which the funds were allotted. The investment spending categories were transportation, education, health, and “other” (a combination of sectors such as water, the environment, municipal...
and local infrastructure, and justice). Furthermore, the government construction and M&E deflators from Statistics Canada’s Provincial Economics Account were used to convert nominal capital expenditures provided by The Ministry of Energy and Infrastructure into real terms—i.e., adjusted for inflation.

**KEY ASSUMPTIONS AND METHODOLOGY**

Aggregate infrastructure investment data were used to “shock” the Conference Board’s provincial economic model of Ontario—that is, show the effect the infrastructure spending has had on Ontario’s economy. The model simulations were performed for the years 2006 to 2010.

**Increased public demand for infrastructure will directly impact the economy and also spread throughout the economy.**

The shock to the Conference Board’s Ontario economic model was to real public construction investment and real public M&E capital outlays. The government construction and M&E deflators from Statistics Canada’s Provincial Economics Account were used to deflate the public investment data provided by the Ministry of Energy and Infrastructure. (Deflators are used to convert nominal capital expenditures into real terms, i.e., adjusted for inflation.) As a point of interest, the two government capital investment deflators have very different growth patterns between 2005 and 2008. Over this period, construction prices advanced strongly—at an average annual pace of 5.7 per cent—as a result of rising construction material costs and wage pressures. On the other hand, the government M&E deflator steadily declined over 2005 to 2007—by an average of minus 3.7 per cent per year—because the appreciation of the Canadian dollar made imported M&E much cheaper. The government M&E deflator was relatively flat in 2008.1

The two deflators were used to convert nominal capital expenditures into their respective real expenditures as measured in constant 2002 dollars. The decline in M&E prices suggests that the government purchasing power for this type of capital grew much more strongly in recent years.

The Conference Board’s macroeconometric model of the Ontario economy was used to quantify the impact of the real capital investment streams estimated for 2006 to 2010. The analysis evaluates the combined direct, indirect, and induced economic impacts, where:

- **Direct impact** measures the value-added2 on the economy of the increased public capital spending on those firms that would either build structures or manufacture equipment. Because demand for machinery and equipment has a high import content, the direct effect on the Ontario economy is muted. Nonetheless, the increased demand will generate domestic activity in the transportation sector.

- **Indirect impact** measures the value-added that the “direct impact firms” generate economically through their demand for intermediate inputs or other support services. For example, increased construction activity will lift demand for utilities, transportation, financial, and insurance services.

- **Induced impacts** are derived when employees of the aforementioned industries spend their earnings and owners spend their profits. These purchases lead to more employment, wages, income, and tax revenues, and can be felt across a wide range of industries.

Thus, increased public demand for infrastructure will not only have direct impacts on the economy (for example, on construction) but will also spread through the economy through a series of multiplier effects. Indirect effects are first felt on demand for industries that are direct suppliers. Second-round induced effects produce a widespread impact (albeit usually smaller) on all sectors of the economy.

1 Data from the Conference Board’s Provincial Outlook forecast were used to extend prices to 2010.

2 Value-added or net output is the difference between total revenue and the sum of expenses on parts, materials, and services used in the production process. Summing the value added across all industries in a region will yield the GDP in that region.
economy, largely through a general increase in consumer spending. The overall economic multiplier is calculated as the sum of all value-added impacts (direct, indirect, and induced) divided by the initial spending on infrastructure (in constant dollars).

It is important to note that the initial constant dollar value of the public capital investment does not result in a one-to-one increase in real GDP. This is because a significant portion of the investment is assumed to go toward the purchase of machinery and equipment, much of which is imported. Moreover, even as demand is lifted for machinery and equipment produced in Ontario, the lift in demand for manufactured goods will require intermediate inputs purchased from suppliers who may be outside the provincial boundaries. This dependence of the supply chain on imported components will determine the level of leakages and the extent to which the overall economic multiplier is reduced.

The Conference Board’s provincial forecasting model captures the sum of the direct, indirect, and induced impacts on Ontario’s economy, based on its estimated historical relationships. The model incorporates a detailed modelling of prices, households, and businesses. It also provides economic impact results for a wide range of economic indicators.

Just under half of the 223,000 new jobs, to be created in 2010, are estimated to be in the services sector, while 33 per cent are in the construction industry.

Some key points and assumptions about the methodology are worth mentioning. The Conference Board’s regional forecasting model contains only a partial accounting of government revenues (including direct and indirect tax revenues). In addition, government accounts in the Conference Board’s national and regional models are based on national accounts data and not on the public accounts. In principle, one can assume that the impact of the shock on a national account and public account basis would be similar. Finally, although the shock has only small effects on costs and prices, these variables do move in response to the lift in economic activity and have a modest dampening effect on the shock results. Price effects are too small to have an impact on monetary policy or the value of the currency.

RESULTS

In real terms, the cumulative $53.6 billion in public infrastructure spending generates a total of $59.3 billion in real GDP over 2006 to 2010. (See Table 3.) In other words, each dollar of real public infrastructure spending generates $1.11 in real GDP. Over the same period, a total of 822,335 person-years of employment are created in the province, with annual job creation expected to peak in 2010 with over 223,000 new jobs, when the unemployment rate edges down 1.3 percentage points. Just under half of the new jobs are estimated to be created in the services sector, while 33 per cent are in the construction industry. The manufacturing and the primary sectors generate roughly 12 per cent and 7 per cent (respectively) of the new jobs. Capital investment spending from the ReNew Ontario program is also estimated to lift personal income by a cumulative $48.7 billion from 2006 to 2010 and add $10.3 billion to corporate profits. Personal income and indirect tax collections are lifted by a cumulative $12.4 billion: 43 per cent accrued to federal coffers, 23 per cent to the province, and the remainder due to a lift in indirect taxes collected by both levels of government.

The impact that the additional boost to infrastructure spending—partly due to the new short-term initiatives to counter the recession—has in 2009 and 2010 is noteworthy. On a calendar-year basis, the level of infrastructure investment rises by $5 billion in 2009 and a further $3.6 billion in 2010. This strong boost to infrastructure spending helps lift real GDP growth by 0.9 percentage points in 2009 and a further 0.4 percentage points in 2010. The boost to employment is similarly impressive. If not for the stimulative impact of the increase in public investment, Ontario’s economy would have lost an additional 70,000 jobs in 2009. In 2010, when infrastructure spending peaks, another 40,000 jobs will be added to the payrolls in the province.
<table>
<thead>
<tr>
<th>Table 3</th>
<th>Total Public Infrastructure Investment—Economic Impact in Ontario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(level difference of shock minus control, except where otherwise indicated)</td>
</tr>
<tr>
<td></td>
<td>2006</td>
</tr>
<tr>
<td><strong>Investment</strong></td>
<td></td>
</tr>
<tr>
<td>Total investment generated ($ millions)</td>
<td>6,753</td>
</tr>
<tr>
<td>Total investment generated (2002 $ millions)</td>
<td>6,644</td>
</tr>
<tr>
<td><strong>Effects</strong></td>
<td></td>
</tr>
<tr>
<td>Real GDP at market prices (2002 $ millions)</td>
<td>10,328</td>
</tr>
<tr>
<td>Personal income ($ millions)</td>
<td>7,798</td>
</tr>
<tr>
<td>Labour force</td>
<td>86,682</td>
</tr>
<tr>
<td>Employment (person-years of employment)</td>
<td>141,855</td>
</tr>
<tr>
<td>Unemployment rate (level difference in rate, percentage points)</td>
<td>−0.86</td>
</tr>
<tr>
<td>Retail sales ($ millions)</td>
<td>2,268</td>
</tr>
<tr>
<td>Housing starts</td>
<td>3,863</td>
</tr>
<tr>
<td>Total indirect taxes ($ millions)</td>
<td>423</td>
</tr>
<tr>
<td>Federal personal income tax collections ($ millions)</td>
<td>793</td>
</tr>
<tr>
<td>Provincial personal income tax collections ($ millions)</td>
<td>472</td>
</tr>
<tr>
<td>Corporate profits ($ millions)</td>
<td>1,055</td>
</tr>
</tbody>
</table>

Sources: The Conference Board of Canada; Statistics Canada.
CHAPTER 5

Other Benefits and Consequences of Public Infrastructure

Chapter Summary

- Infrastructure construction spending is useful in countering the business cycle over the short term, and the completed infrastructure projects can lead to productivity gains over the medium term, and even the long term.

- Numerous studies have highlighted the links between transportation and the value of time, labour market issues, and costs imposed by congestion, pollution, and global warming.

- Improved transportation infrastructure boosts productivity by promoting agglomeration—the clustering of firms in an urban area. Investment in health care and education improves a population's health and educational attainment.

- On the downside, increased roads and highways can lead to urban sprawl, increased air pollution, and more greenhouse gas emissions.

- There is a high degree of interdependence between the quality and quantity of public infrastructure, the performance of a society's business sector and, ultimately, the quality of life of its citizens.

In addition to the relationship between public infrastructure, the macroeconomy, and private sector performance and competitiveness, the literature also contains numerous studies of links between transportation and the value of time, labour market issues, costs imposed by congestion, pollution, and global warming. The effect of transportation on urban issues such as agglomeration has generated a great deal of interest in the media. Moreover, investment in health care and education carry innumerable benefits for the long-term health and quality of life of citizens.

PUBLIC INFRASTRUCTURE AND LABOUR MARKETS

Without a proper transport network in place, workers would have to seek employment close to home in much smaller production units. A sound public infrastructure system enables workers to move from inefficient production systems to systems that can exploit economies of scale, specialization, agglomeration, and trade.

One of the most obvious benefits from a superior transportation system is a reduction in the time that people spend travelling back and forth from work. The benefit of an improved transportation network, therefore, is the value of time that is freed up for people to do other things that cannot be done while commuting. Other benefits, including the increase in the “connectivity” between locations, are not necessarily accounted for in people’s perceptions of the opportunity cost of travel.
This section examines the results of some of the research on the relationship between public infrastructure and the functioning of labour markets. Much of the research on this topic was completed by Steve Gibbons and Stephen Machin.¹

**THE VALUE OF TIME**

A key component of understanding the link between travelling to work and labour supply is the value of time when travelling. The theoretical research on this issue suggests that the opportunity cost of time spent commuting is the wage rate plus the enjoyment attained from additional time at work, minus the enjoyment of commuting. Therefore, if work is liked less than commuting, the value of marginal travel time savings would be less than the wage rate.

From the extensive empirical evidence on the value of travel time savings, there is a general consensus that average values of travel time savings are less than the wage rate. Kenneth Small’s summary of the evidence concludes that the value of travel time savings for the trip to work is about 50 per cent of the gross wage.² Subsequent research by Peter Nijkamp and Jan Rouwendal generally confirmed these results.³ If commuting time savings are valued at less than the wage rate, this implies that travel time is preferred to working time at the margin, a finding that has important implications for the decision to improve transportation infrastructure. A reduction in commuting time due to superior roads could encourage workers to move further away from their work and end up extending commuting time instead of increasing work hours. This view is confirmed by David Ory’s research, which found that only 40 per cent of a sample of San Francisco workers disliked or strongly disliked commuting.⁴

Some economists have an alternative explanation for the conclusion that travel time savings are valued less than the wage rate. If work hours are fixed, implying that changes in commuting time come out of leisure time, then the wage may not be the relevant opportunity cost to consider. According to Gibbons and Machin, this explanation assumes that the labour markets may be in disequilibrium due to work time constraints such that wages are greater than the marginal value of leisure time. This implies that people would be willing to put in more hours if it were possible—that is, if they did not have other commitments outside work that prevented them from working more.⁵

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**A reduction in commuting time, due to superior roads, could encourage workers to move further away from their work and end up extending commuting time.**

A report prepared for Transport Canada examining the valuation of freight time savings noted that the available evidence is limited and that there is a wider variance in values than there is for estimates of time savings for passenger travel.⁶ Freight travel time savings vary with the type of freight being shipped and other characteristics, notably the urgency of shipment. There is growing evidence that the most important part of freight travel time is not necessarily the reduction in travel time per se but rather the increased reliability of the delivery and schedule time. The literature reveals that reliability and schedule adherence are valued significantly more than freight time savings. Reasonable estimates of the value of average freight travel time savings range between $45 and $200 per shipment.

Some research has focused on the impact of transportation infrastructure (not always public infrastructure though) on international trade. For example, transit times are an important barrier to trade, and the speeding up of sea transport through containerization and faster ships, together with the rapid growth in air transport, has lowered trip times by an amount equal to a significant reduction in tariffs (around 23 percentage points since 1950) according to David Hummels.⁷ Hummels also concluded that the

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¹ Gibbons and Machin, *Transport and Labour Market Linkages.*
² Small, *Urban Transportation Economics.*
³ Nijkamp and Rouwendal, “Living in Two Worlds.”
⁴ Mokhtarian and Ory, *The Impact of Telecommuting.*
⁵ Gibbons and Machin, *Transport and Labour Market Linkages.*
⁷ Hummels, *Have International Transportation Costs Declined?*
total transport barrier to trade includes overland transport, which can often double or triple transport costs, especially if the overland transportation network is weak.

Public transportation infrastructure can affect the desirability of places to live for reasons other than commuting.

Anne-Célia Disdier and Keith Head concluded that distance is still an important deterrent to trade as reflected by the estimated coefficients on distance in gravity models of trade flows. By the 1990s, distance barriers to trade had increased to the point where distance was a 24 per cent greater obstacle to trade than it was in the 1960s. This seems to reflect a change in the composition of transport costs, in particular a lowering in handling charges relative to distance charges. Clark concluded that international trade can be sharply reduced by inferior public transportation infrastructure and poor ports.

PUBLIC INFRASTRUCTURE AND RESIDENTIAL LOCATION

Transportation infrastructure has an important impact on where people live and businesses are located, something that is reflected in land values and migration patterns. The impact of more developed transportation infrastructure can be positive through improved accessibility or negative as a result of adverse environmental effects. Most of the research in this area compares property price changes in a region subject to public transportation improvements with price changes in a nearby control group that is deemed not to be affected by the upgrade in transportation.

Many of the studies report positive impacts of differing magnitudes, and others note the importance of price changes actually anticipating the improvements in transportation. Gibbons and Machin revealed that housing that was close to the London Underground held a premium price. They also concluded that property prices increased as a result of reductions in home–station distance due to the opening of new subway stations.

Public transportation infrastructure can also affect the desirability of places to live for reasons other than commuting. One of the reasons for the existence of cities is that they enable goods and services—including restaurants, theatre, opera, and museums—to be consumed at the point of production. Edward Glaeser, Jed Kolko, and Albert Saiz found that these consumption patterns are linked to urban growth in the United States, and their availability is a factor in residential location. This could explain why many workers reverse-commute—that is, they live in central neighbourhoods and work in the suburbs—despite the higher cost of rent and housing in central areas. Transportation infrastructure has a crucial role to play in increasing the geographical range over which these services are accessible and can also affect the size of the pool of workers who look for city amenities. Glaeser et al. also concluded that much of the concentration of poverty in cities is due to the fact that people with low incomes benefit from the availability of public transportation in the inner part of cities.

TRANSPORTATION AND TRAVEL DEMAND

The way in which demand for transportation and travel changes when commuting trips are shortened as a result of improvements in public transportation is relevant for city planners assessing the distributional effects of transport policy. How do commuters respond to travel cost reductions? International estimates summarized by Small and Nijkamp are wide-ranging, suggesting that a 10 per cent decrease in transportation costs can lead to an increase in demand of between 1.5 per cent and 8 per cent. Still, even a modest increase in the number of commuting trips suggests that labour supply has changed in some way.

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8 Disdier and Head, “The Puzzling Persistence.”
9 Clark et al., Port Efficiency.
11 Gibbons and Machin, “Valuing Rail Access.”
12 Glaeser et al., Consumer City.
13 Ibid.
14 Small, Urban Transportation Economics.
15 Nijkamp and Rouwendal, “Living in Two Worlds.”
TRANSPORTATION, HEALTH, AND HUMAN CAPITAL

Although difficult to quantify, there is evidence that public spending on transportation infrastructure can affect health and human capital indirectly. Human capital can be improved because better transportation infrastructure reduces the costs of commuting to educational institutions. In theory, poor transportation could be a barrier to entry into tertiary education, particularly for lower-income students. Greater distance increases direct costs, thereby making participation in higher education less likely, especially for those already facing high costs. Card and Frenette found that people living farther away from universities were less likely to attend these institutions and that the increased distances had a greater impact on people from lower income groups.

Agglomeration is the clustering of firms in an urban area. The interaction between firms and workers enable the sharing of knowledge and the development of new ideas, and also gives workers a greater choice of jobs.

The empirical links between transportation, commuting time, and health are difficult to pin down because of the numerous contradictions that come up when analyzing this issue. A better road system that lowers commuting time and, potentially, stress is presumably a positive development. However, an improvement in transportation that causes people to walk or cycle less could be detrimental for health. Similarly, a policy to restrict traffic speed—such as installing speed bumps—can increase commuting time (a bad development) but also reduce the chances of injury and death. Diane Lacaille found that commuting difficulties in Canada resulted in an increased likelihood of worker-disability for those with rheumatoid arthritis. Koslowsky concluded that workers faced with commuting impediments like congestion and poor roads reported higher levels of stress than other workers. The results did not change significantly for car or bus commuters.

AGGLOMERATION

Agglomeration refers to the clustering of firms in an urban area. The interactions between firms and workers enable the sharing of knowledge and the development of new ideas. Agglomeration also provides workers with a greater choice of jobs and gives firms access to a larger pool of potential workers. These developments improve productivity.

Economic effects of agglomeration include:
- knowledge transfers and spillovers due to greater interactions
- access to labour—increased availability of specialized skills
- input effects—provision of inputs in a more efficient manner
- consumption benefits—people live in dense areas with additional leisure opportunities, firms locate nearby so they can have access to skilled labour

There are two types of agglomeration economies:
- localization economies—firms derive benefits from being close to other firms in the same sector (e.g., Silicon Valley)
- urbanization economies—firms derive benefits from overall city size (access to large labour market, business inputs)

The theoretical literature on agglomeration is vast, particularly since the publication of Paul Krugman’s influential work in the early 1990s dealing with international, urban, and development economics. Wide-ranging empirical work completed by Stuart Rosenthal and William Strange and Daniel Graham has examined the effects of agglomeration on production and productivity. Graham concluded

17 Frenette, “Access to College and University.”
20 Krugman, “Increasing Returns.”
22 Graham, Wider Economic Benefits.
that employment density is positively related to productivity in some industrial sectors. Specifically, for manufacturing, a 1 per cent increase in employment density in an urban area is associated with a 0.04 per cent increase in manufacturing productivity and a 0.12 per cent gain for services. The U.K.’s Eddington Transport Study concluded that the doubling of a city’s size in Great Britain results in an increase in productivity ranging from 3 to 8 per cent per year.23

Very little of this research has looked at the explicit role of transportation in agglomeration, but its role in contributing to agglomeration economics is apparent. Transportation within and into cities is crucial for the existence of agglomeration economics since improved transportation enables cities to increase in size and density, a development that permits producers to serve multiple markets.

Rod Eddington simulated the effect on densities, in urban parts of Great Britain, of reducing the costs of road travel into large cities.24 He found that agglomeration benefits were particularly high for areas of London close to Heathrow Airport. Benefits were lower for the areas along the M4 highway and seaports in England. On an industry basis, agglomeration benefits were more

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**Public Infrastructure and Air Pollution Costs**

While there is substantial literature and evidence about the benefits of public infrastructure, some researchers have also examined the potential costs and negative repercussions of adding to road and highway infrastructure, particularly the cost of increased air pollution and greenhouse gas emissions. *Towards Estimating the Social and Environmental Costs of Transportation in Canada*, a UBC study for Transport Canada,1 examined costs such as those that result from air pollution—the direct effect of emissions from transportation on health and economic activity.

The study derived the following estimates for the cost of air pollution attributable to transportation in Canada:

- **Urban passenger transport (per passenger kilometre, 2002 $)**
  - Private vehicle 0.00842
  - Urban transit 0.00331
- **Freight transport (per tonne kilometre, 2002 $)**
  - Truck 0.00503
  - Rail 0.00173
  - Marine 0.00074
  - Aircraft 0.00003

To calculate these costs, the authors of the study made assumptions about the value of a statistical life, morbidity, passenger occupancy rates per vehicle, and emissions. Their cost estimates turned out to be roughly proportional to the occupational rates assumed. When, for instance, the occupancy rate for urban private vehicles increases from 1.4 to 1.5 passengers per vehicle, the cost estimate decreases by 6.6 per cent—from $0.00842 to $0.00786 per passenger kilometre. Similar results were reported for other modes. In general, these results were also sensitive to the passenger occupancy rate.

The study also considered the impact of transportation on greenhouse gas emissions. The authors noted that the global climate system is very large and that there are decades of long lags between emissions at the present time and impacts that may occur in the future. How these impacts can be projected is examined along with the economic and environmental modelling issues that arise when trying to assess the effect of climate change. Their estimates of the unit costs of GHG emissions range from 0.00172 for private vehicles to 0.000420 for urban transit (in 2002 $, per passenger kilometre).

The study’s cost-benefit analysis of efficient GHG policies is based on earlier work by Nordhaus.2 At what the authors refer to as an “efficient level” for GHG emissions, paying roughly $4.78 billion per year to reduce emissions would yield social and environmental benefits worth $9.55 billion per year. The study notes that the many sources of uncertainty surrounding estimating GHG emissions linked to different transportation systems make these types of analyses risky. Uncertainties arise from factors including a lack of knowledge of basic scientific relationships, statistical variation, measurement error, variability, and subjective judgment. These problems are compounded by the global scale of climate change.

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23 Eddington, *The Eddington Transport Study*.
24 Ibid.
important for financial services and aerospace and less so for pharmaceuticals. Eddington’s results did not attempt to account for the costs involved in attaining lower commuting time or the demand responses to land-use changes attributable to lower transportation costs.

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**In the future, if transport costs approach zero, agglomeration may disappear because of easy access to firms and consumers.**

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Empirical work in Maryland found a significant association between transportation supply and agglomeration economies, as well as firm-specific characteristics. An increase of 1 mile of primary highways per square kilometre was associated with a 66.2 per cent increase in the likelihood of firms not relocating.25 Better highways increase the potential for agglomeration economies and discourage re-location.

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Eddington also discussed some other broad issues surrounding agglomeration economics and what the future may hold:

- The congestion and land scarcity that result from agglomeration can lead to dispersion, a counter-force to agglomeration.
- When transportation costs are high (as in ancient times), dispersion occurs because firms locate to meet final demand for people in each region.
- As transportation costs decrease, as a result of technology advances, firms agglomerate to take advantage of closer contacts.
- However, in the future, if transport costs approach zero, agglomeration will disappear, because access to firms and consumers will become so much easier.

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25 Targa et al., “Influence of Transportation.”
Conclusion

Chapter Summary

- Productivity in Ontario has benefited from strong infrastructure growth more than Canada as a whole and more than other developed economies.
- Growth in the stock of infrastructure in Ontario explains about an eighth of the labour productivity gain over the past 30 years.
- Each dollar of real public infrastructure spending generates $1.11 in real GDP. If not for infrastructure investments, 70,000 more people would have lost their jobs in 2009 as a result of the economic downturn.
- Spin-off benefits from investment in infrastructure include improved health, improved educational attainment, and lower transit times. But increased roads and highways can also lead to urban sprawl, increased air pollution, and more greenhouse gas emissions.

The literature reviewed in Chapter 2 is widely in agreement that infrastructure contributes positively to output and productivity in developed countries. First, following the lead of previous researchers, we confirmed this finding with an empirical exercise estimating the impact of public capital on private sector labour productivity. Indeed, we found that growth in the stock of infrastructure in Ontario explains about an eighth of the labour productivity gain over the past 30 years. This trend increased in the 2000s alongside increased infrastructure spending; infrastructure accounts for almost a quarter of the growth in labour productivity in this decade.

Infrastructure is important to any economy: Ontario has benefited from strong infrastructure growth—more than Canada as a whole and more than many other developed economies.

Next, an economic impact assessment was conducted to estimate the effects of the ReNew Ontario investment program. We found that each dollar of real public infrastructure spending generates $1.11 in real GDP. Furthermore, infrastructure spending provides a sizable increase in employment: from 2006 to 2010, a total of 822,335 person-years of employment are created in the province. If not for the investment in infrastructure, we estimate that 70,000 more people would have lost their jobs in 2009 as a result of the economic downturn.
Last, we looked to the literature on the subject for other benefits from investment not explicitly quantified in this study. The many spin-off benefits (and in some cases costs) from investment in infrastructure include improved health, improved educational attainment, and lower transit times. However, some studies also suggest that increased roads and highways can lead to urban sprawl, increased air pollution, and more greenhouse gas emissions. Overall, though, reviewing the existing literature leads to the conclusion that there is a high degree of interdependence between the quality and quantity of public infrastructure, the performance of a society’s business sector and, ultimately, the quality of life of its citizens.
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