The Economic Impact of Canadian P3 Projects

Why building infrastructure ‘on time’ matters

November 2016

Canadian Centre for Economic Analysis

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The Canadian Council for Public-Private Partnerships
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Using CANCEA's *Prosperity at Risk* platform, the research was conducted by Matt DesRosiers and David Stiff of CANCEA.

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EXECUTIVE SUMMARY

Background

Public infrastructure – such as roads, bridges, transit systems, water/wastewater systems, schools, hospitals, courts, and jails – is critical for our society's collective sustainability and prosperity. It provides the places and spaces within which we live, work, and play. That said, it is generally agreed that Canadian governments have historically underinvested in public infrastructure.

We believe that, in general, researchers have not provided decision makers with a full understanding of the risks and rewards of infrastructure investment. As demonstrated in the literature, traditional economic models have not fully captured the value of infrastructure assets (and public investments in them) by ignoring the many linkages that public infrastructure lay down in a complex economic system. This means that, perhaps until recently, individuals and businesses have not fully connected underinvestment in public infrastructure to their personal prosperity.

This report brings a systems approach and agent-based modeling to the world of public-private partnerships (P3s) in order to calculate a more realistic economic impact of Canadian infrastructure projects procured this way. Further, we aim to add to the conversation around P3s by quantifying – beyond the benefits traditionally outlined – the significant economic value from delivering such assets for public use sooner, as productive infrastructure projects are not just about the type, size, and location of an asset, but *when* it is built.

A systems approach and agent-based modeling is used to realistically evaluate the use of public-private partnerships in the delivery of Canadian infrastructure.

Results at a glance

Using CANCEA's award winning agent-based simulation platform – *Prosperity at Risk* (PaR) – and project-level data from the Canadian Council for Public-Private Partnerships (CCPPP)[1], we investigate the economic impacts of 200 Canadian P3s that have at least reached 'financial close' (i.e., they will soon start construction, are under construction, or construction is complete) since 1993. Four out of five of these projects have been provincial/territorial (half of which have been healthcare projects), with most of the remaining projects having been municipal. The total agreement costs for these projects exceed $110 billion.

The 200 projects were divided into five asset classes (health, transportation, utilities, justice, and other) and grouped by location within the four largest provinces and the rest of Canada, for a total of 25 'project groups'. [2] The economic significance of these groups of projects was estimated by removing the specific individual sets of investments from history and examining the changes in how the economy might have evolved with the lower stock of infrastructure.

[1] Data in the CCPPP database is drawn from publicly available sources.
[2] Quebec had no P3 projects in the utilities sector and there is one multi-province project.

Of the P3 projects delivered and evaluated, the 30 year cumulative economic benefits for each million dollars invested are[4] between:

- $1.1 million and $4.2 million of economic activity, including 'systemic benefits'[5]
- $0.5 million and $1.6 million of private capital investment
- 10 and 37 job years (i.e., full-time equivalents)
- $0.5 million and $1.9 million of additional wages
- $0.4 million and $1.1 million in combined federal/provincial tax revenue

Taken together as a portfolio – that is, evaluating the impact of not having undertaken *any* of the 200 projects rather than investigating by type-province groupings individually – the overall GDP impacts grow from a group-wise average of $2.4 per dollar invested to $3.6 per dollar invested. In other words, the total economic value of these projects is more than the sum of their parts. Further, about half of the overall GDP impacts are due to systemic effects because the economy has benefited from a broad portfolio of assets across the country. Over the 30 years evaluated, the portfolio as a whole supports per year, on average:

- $14 billion of economic activity ($4 billion of which is the investment itself)
- $4 billion of private capital investment
- 115,000 job years
- $5 billion of additional wages
- $4 billion of combined federal/provincial tax revenue

By location/ asset class, $1 invested supports between $1.1 and $4.2 of economic activity, or $2.4 on average.

All 200 P3 projects studied collectively support $3.6 for every $1, creating value greater than the sum of their parts.

Because P3s are simply a delivery mechanism for (generally large-scale) public infrastructure assets, these results would largely apply regardless of the procurement method used. However, this assumes that the projects would have actually moved ahead (or even simply have been delivered on time) regardless of the procurement method used. Understanding that value is truly important in the understanding of P3s.

[4] In most of these, transportation investments are near or at the top of the range.

[5] These are the economic impacts of an infrastructure asset being *used* rather than those that come from simply *building* it, and include variables not traditionally examined under the economic lens, such as 'productivity coupling' and consequent impacts upon asset values (refer to Appendix A for more information).

The economic value of timing certainty

Previous CANCEA research has highlighted that the building of infrastructure itself is important, but misses the value of the asset itself, if it is built at the right scale, in the right place, and at the right time. If procurement stands in the way of delivering or enabling a vital public service at that time, then the economy suffers. By evaluating the economic importance of such timing certainty, this paper adds a new perspective to the debate about the use of P3.

The most fundamental question in this regard is whether there is a timing difference between the two methods of delivery. Numerous studies and agency reports have agreed that once a contract is signed, P3 projects tend to be delivered on time whereas (at least large and therefore comparable) traditional projects do not. However, these analyses usually ignore the pre-contract time spent on planning and procurement that is typically much longer for P3s. While this longer lead time likely means better due diligence, claims that P3 projects are delivered on time, while true from a given starting point, do not provide the whole picture.

Utilizing studies that investigate 'optimism bias' (the percent difference between an expected value and the actual result), we find that, as advertised, the use of P3 is most effective for large, complex projects, but not necessarily for smaller, more straight-forward ones. To estimate the full impact of delays of large infrastructure projects on the Canadian economy, a full sensitivity analysis was undertaken examining the impact of delays ranging from 0 to 5 years with P3 investment ranging from 0 to double the total of all P3 investments included in this analysis. This shows that the economic value of a project (or portfolio of projects) is highly sensitive to its size and timeliness of delivery.

Since infrastructure plays a critical role in the efficient operation of the economy, the effect of delays today compound over decades. As a result, the effective present-day value of an infrastructure project is reduced significantly for larger projects and greater delay in implementation. For projects of a given size, the impact on Canadian economic activity increases quickly as the length of delay increases. Similarly, for a given delay, the impact on GDP increases with project size. That is, for smaller projects, the impact of delays even up to a few years has a relatively small effect, but as the projects grow in size, the cost of delays to the Canadian economy quickly become more significant.

> Taken together, a one-year delay for a typical infrastructure portfolio of $100 billion reduces its 30 year value by the equivalent of nearly 10% of the total project value. These impacts are of a similar magnitude as the aggregate value-for-money for these projects.

These benefits apply to both large individual projects and portfolios of smaller projects of equal value. While the majority of individual P3 projects completed or underway in Canada are not 'megaprojects' (i.e., their adjusted agreement costs are less than $1 billion), taken as a single portfolio, the total adjustment agreement exceeds $110 billion putting it in the magnitude where delays start to have a significant impact. If the size of infrastructure projects continue to grow, the impact of delays in implementation of quality infrastructure projects to the Canadian economy will become increasingly significant.

Putting this into the Canadian context, of the 200 projects studied, 129 were operational and had sufficient data on the timing of the entire procurement and construction periods. By this measure, P3s typically take 6 years on average. When factoring in at least another year or two to get to the procurement stage from inception, we find that the delay avoided by using P3s is somewhere around 1-year on average (8 year project * 12.4% timing improvement as found in Australia).

Taken together, a one-year delay for a typical infrastructure portfolio of $100 billion reduces its 30 year value by the equivalent of nearly 10% of the total project value. As the portfolio increases in size, the cost of delays increase faster than the value of the projects. For example, for a portfolio 50% larger (i.e., worth $150 billion), the economic cost of a one year delay increases by 65% to almost 16% of the project's total value. To put this into context, these economic impacts are of a similar magnitude as those shown in value-for-money (VfM) assessments. This means that as the portfolio of P3 projects continues to grow (which the relatively significant pipeline of projects and planned public infrastructure investment would suggest), this value will continue to accumulate.

Conclusions

P3s are not a panacea, but research does show that for larger, more complex projects, P3s do provide value as advertised.

The economic impacts of the 200 Canadian P3 investments investigated (grouped by asset class and location) are significant, ranging from $1.1 to $4.2 (with a weighted average of $2.4) in GDP supported per dollar invested. Taken as a portfolio, these projects have supported significant economic activity – $3.6 in GDP per dollar invested. In other words, the total economic value of these projects is more than the sum of their parts, showcasing the systemic benefits of a larger portfolio of quality public infrastructure. However, these benefits would have occurred regardless of the procurement method *if built on the same schedule*.

The real economic benefits of P3s come from two places. The first is the now traditional VfM – that is, in the sharing (and therefore effective management) of risks between the private and public sectors. Looking at projects that went ahead as P3s where VfM assessments are public, value-for-money represents a weighted average of 24% of the respective public sector comparators.

The second area of value – which this report is the first to quantify – is in the economic value of reduced delays – that is, getting assets on the ground faster. Completing a typical $100 billion infrastructure portfolio one year sooner would mean an additional 10% of project value. This economic boost is of a similar magnitude as value-for-money. This proves that much of the (previously unquantified) benefit of P3s are in the delivery of large and complex projects on time.

If these additional values (VfM and on-time delivery) applied to the portfolio of 200 P3 projects studied, the potential value add would be upwards of $38 billion.

1.0 INTRODUCTION

Public infrastructure – such as roads, bridges, transit systems, water/wastewater systems, schools, hospitals, courts, and jails – is critical for our society's collective sustainability and prosperity. It is the surface upon which we live, work, and play. The level of public infrastructure investment in Canada by all orders of government has varied considerably over the past half century. As a percentage of Canada's GDP, it has ranged from a high of 4.5% in the mid-sixties to a low of 2% in the mid-eighties. Over the last decade, the trend has reversed with increased investment peaking with the stimulus spending in 2009. (Public infrastructure in Canada is predominately funded by provinces/territories and municipalities, at about 50% and 40% respectively on average over the last decade.) By the end of 2014, the value of public infrastructure in service in Canada sat at over $1 trillion[6], or nearly $30,000 per person.

That said, it is generally agreed that Canadian governments have historically underinvested in public infrastructure. Some governments, like the Province of Ontario, have even highlighted this fact (Ontario Ministry of Infrastructure 2011). Estimates of an 'infrastructure deficit' range widely (due to different definitions, data sources, and methodologies), but most agree that it is significant, particularly with respect to certain asset classes. There is evidence, such as that provided in previous CANCEA research (Stiff and Smetanin 2010), that suggests that, even after significant increases over the last decade, governments in Canada are still not collectively investing in public infrastructure at an 'optimal' level.

This report brings a systems approach and agent-based modeling of infrastructure to the world of public-private partnerships in order to calculate a more realistic economic impact of Canadian projects procured this way.

We believe that, in general, researchers have not provided decision makers with a full understanding of the risks and rewards of infrastructure investment. As shown in Smetanin and Stiff (2015) and Smetanin and Yusuf (2016), traditional economic models have not fully captured the value of infrastructure assets and public investments in them by ignoring the many linkages that public infrastructure lay down in a complex economic system. This means that, perhaps until recently, individuals and businesses have not fully connected underinvestment in public infrastructure to their personal prosperity.

This report will therefore bring a systems approach and agent-based modeling of infrastructure[7] to the world of public-private partnerships (P3s) in order to calculate a more realistic economic impact of Canadian projects procured this way. Further, we hope that this paper adds to the conversation around P3s by quantifying – beyond the benefits traditionally outlined – the significant economic value from delivering such assets for public use *sooner*, as productive infrastructure projects are not just about the type, size, and location of an asset, but *when* it is built.

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[6] Statistics Canada CANSIM Table 031-0005: government sector gross stock, excluding intellectual property.
[7] See Appendix A or Smetanin and Stiff (2015) or Smetanin and Yusuf (2016) for more details.

Before doing so, however, we will discuss what P3s are (and are not), why the procurement method is used, and try to clarify a few misconceptions.

1.1 The 'curse' of the megaproject

It has become fairly common to read a news headline about a major infrastructure project having blown through its budget or construction timelines. Research suggests that such cost overruns and construction delays "are a global epidemic. They affect projects conducted by national, provincial, and local government, and by private sector organizations; they are a feature of a wide diversity of infrastructure project types; and they have been stubbornly persistent throughout history" (Siemiatycki 2015). Recent or ongoing Canadian examples include:

- Toronto-York Spadina Subway Extension (TYSSE) – a six stop, 8.6 km extension of the Line 1 subway in Toronto into York Region has been plagued by problems such as an 18 month delay in its start date, frequently shifting station design plans, and two budget increases totalling $550 million.[8]
- Edmonton's Federal Building redevelopment – renovations to a Government of Alberta office complex hit numerous hurdles such as requirements to reinforce the foundation and asbestos removal, delaying completion by four years.[9] (Edmonton has also suffered delays to the Walterdale Bridge, Metro LRT line, and the 102nd Street-Groat Road Crossing.)
- Saskatchewan highways – a report to the Saskatchewan Ministry of Highways and Infrastructure found that 51% of their contracts were completed late, the majority of which were preventable delays, largely due to late contractor start dates or contractors leaving before work is completed (McNair Business Development Inc. 2014).
- Labrador's Muskrat Falls hydroelectric project – development of a dam and hydro station on the lower Churchill River to provide power to Newfoundland and onto Nova Scotia via undersea cables has seen estimated costs rise from $7.4 billion to $11.4 billion (including financing) and in-service dates pushed back by more than a year due to harsh conditions and poor execution.[10]

As these examples suggest, cost overruns and timing delays are often borne of multiple issues, including poor schedule management, trade strikes, unknown site conditions, harsh environmental conditions, design errors, delivery delays of core elements, scope changes, or inspections by other authorities having jurisdiction (Hanscomb 2015). And delays and overruns are often correlated, with every year of delay causing an average cost increase of nearly 5% on its own (Flyvbjerg, Holm and Buhl 2004).

In fact, Bent Flyvbjerg, Chair of Major Programme Management at Oxford University's Saïd Business School, has written extensively on megaproject (mis)management and found, along with colleagues, that:

- Nine out of ten transportation projects costing at least $100 million experience a cost overrun, averaging 28%, with fixed rail projects averaging overruns of 45%, fixed-link bridges and tunnels

[8] See: CBC News (2016).
[9] See: Hixson (2015).
[10] See: Bailey (2016).

34%, and surface roads 20% – a pattern common across all countries and years studied (Flyvbjerg, Holm and Buhl 2002) & (Flyvbjerg, Bruzelius and Rothengatter 2003);
- Hydro dam projects see an average cost overrun of 90% with no improvement on average over 70 years (Ansar, et al. 2014);
- Olympic Games from 1962 to 2012 saw average cost overruns of 179% relative to the respective Games' bids (Flyvbjerg and Stewart 2012); and
- IT megaprojects experience an average cost overrun of 27%, with one out of six hitting overruns of 200% on average – a pattern common among both public and private projects and across countries studied (Flyvbjerg and Budzier 2011)

As such, Professor Flyvbjerg wrote a 2013 article for *New Scientist* titled 'Mega Delusional: The Curse of the Megaproject', which outlined some of the biases and behaviours that often lead to such overruns.

Given these headlines, it is understandable that public frustration would develop. So governments have naturally looked to limit their exposure to this 'curse' and thus limit a 'headline risk'. The proposed answer: public-private partnerships[11] (P3s or PPPs).

1.2 What are P3s?

There are many definitions of 'public-private partnership'. As typically understood in the Canadian infrastructure context:

> *"[P3s] can be defined as a joint, cooperative arrangement between a private sector consortium and a public sector agency for (two or more of) the services required to: a) design, b) build, c) finance, d) operate, and e) maintain the infrastructure assets needed to deliver a public service. Cooperation between the two parties is structured with long-term, integrated contracts that serve to transfer risks (at a cost) from the public to the private sector when the private sector is better placed to manage those risks."* (Boothe, et al. 2015)

Traditional procurement involves the public sector handling most of these five key components to creating an infrastructure asset in order to deliver or enable services, and hiring the private sector to build (or design and build) the assets.

But P3s are different and "are really extensions of contracting-out to a larger number (and different set) of the tasks listed above" (de Bettignies and Ross 2004). P3s are generally applied to projects where:

- A private player (typically a consortium of players, uniquely formed for each bid opportunity as a project-specific corporation) can have a significant say in the design of the eventual infrastructure asset and therefore take on some of the risks involved in constructing it;
- The deal size is significant, typically *at least* $50 million (depending on the jurisdiction);

[11] Other names are sometimes used, but the definitions here will apply just the same. For example, the Ontario government uses the term 'Alternative Financing and Procurement' (AFP).

- The project is fairly complex and combinable across contract components so that there is an opportunity for a reasonable sharing of risks; and
- A competitive market exists in which multiple bids would be likely.

As described further in section 3.2 below, one of the key difference between P3s and traditionally procured projects is the sharing of risks and decision-making, "which contrasts with the 'supplier' relationship in which the government decides exactly what it wants and buys it and the 'public enterprise' model in which the government produces the services with no private sector involvement" (de Bettignies and Ross 2004).

Another key feature of P3s is that they are *financed* (wholly or partially) by the private sector. One reason for this is that the private sector has extensive experience with rigorous and disciplined stewardship of private assets, of which there are much more than public assets (Gill and Dimick 2013), and therefore is well-suited to manage many of the risks of designing, building, and maintaining them. Further, by providing a 'stick' (financial risk, penalty payments, withholding of payments until the project is substantially completed) and 'carrot' (a risk 'premium', more control), those executing the project are provided with significant incentive to do so on time and on budget.

To be clear, P3s are simply a *delivery* mechanism for (generally large-scale) public infrastructure assets and which, in Canada at least, remain publically-owned in the end. Therefore, decisions on how to prioritize and whether to move ahead with a project are quite separate from the decision of whether to procure it traditionally or via P3. That is, prospective projects are still largely analyzed and put forward by civil servants and then approved by politicians (e.g., a provincial minister and Treasury Board, or a municipal council). Special purpose P3 agencies – such as Infrastructure Ontario, Partnerships BC, SaskBuilds, or PPP Canada – then (or sometimes concurrently) provide analysis and advice on the appropriate delivery method. Other owners, such as municipalities or provinces/territories without such agencies, receive similar expert advice through other means (e.g., specialized government authorities, private advisory service providers). This advice is often *required* for projects costing more than some set threshold (e.g., $50 million or $100 million). If a decision is made to move ahead with the project as a P3, these authorities then typically run the procurement process and monitor progress (Siemiatycki 2013).

As will be discussed further in section 3.0, P3s provide cost and time certainty to governments. In practice, this requires the payment of a 'risk premium' to the consortium. As such, P3s are akin to purchasing insurance against headline risk. "Purchasing this type of insurance through a [P3] delivers value only for the largest, most complex, and riskiest… infrastructure projects, for which major cost overruns are a likely occurrence" (Siemiatycki 2015). That is why even the strongest supporters of P3 do not believe that the method is a panacea to be used in all cases.[12]

[12] See, for example: Thorne (2016).

2.0 P3S IN CANADA

The history of Canadian P3s is often split into two 'waves'. The first, through the 1990s and early 2000s, focused on the international rationale for P3s at the time – namely to reduce public funding requirements, transfer some of the demand risk (i.e., what happens if no one shows up to use the asset?) to the private sector and, in some cases, to realize off-balance sheet accounting (Siemiatycki 2013). The results of these first wave projects are typically seen as decidedly 'mixed', suffering from the challenges of "transforming a good theoretical idea into practice" (National Bank of Canada 2011). As such, governments in Canada have moved away from these rationales and thus projects that are aligned with them.

In response to the many criticisms of the first wave, the last decade's P3s have helped Canada become a world leader, with the creation of provincial and federal agencies to act as 'centres of excellence' for P3 delivery. For example, as of spring 2015, over 40 jurisdictions had visited Infrastructure Ontario to understand how their experience with P3s can be exported (Clark 2015). Other organizations, such as Service Works Global and the New Zealand Council for Infrastructure Development have written about the success of the Canadian P3 model and the need to copy it.

As such, second 'wave' projects have had much in common, and P3s have now become "increasingly institutionalized as the model of choice for delivering large-scale public infrastructure projects." (Siemiatycki 2013).

2.1 Projects

Based on data[13] from the Canadian Council for Public-Private Partnerships (CCPPP), which keeps a thorough database on all P3 projects across the country, there have so far been 200 Canadian P3 projects that have at least reached financial close (i.e., they will soon start construction, are under construction, or construction is complete) since 1993. Four out of five of these projects have been provincial/territorial (half of which have been healthcare projects), with most of the remaining projects having been municipal.

Figure 1 and **Table 1** show that, by asset class and location[14], two out of five of these P3s have been in the healthcare sector and roughly half have been in Ontario. However, **Figure 2** and **Table 2** show that when looking at projects by dollar value (i.e., nominal agreement costs), transportation projects comprise over 40% and the proportion located in Ontario jumps to roughly 60% (significantly higher than the province's Canadian population share of approximately 38%). These shifts are largely due to the same

This report examines 200 P3 projects, based on project-level data from the Canadian Council for Public-Private Partnerships

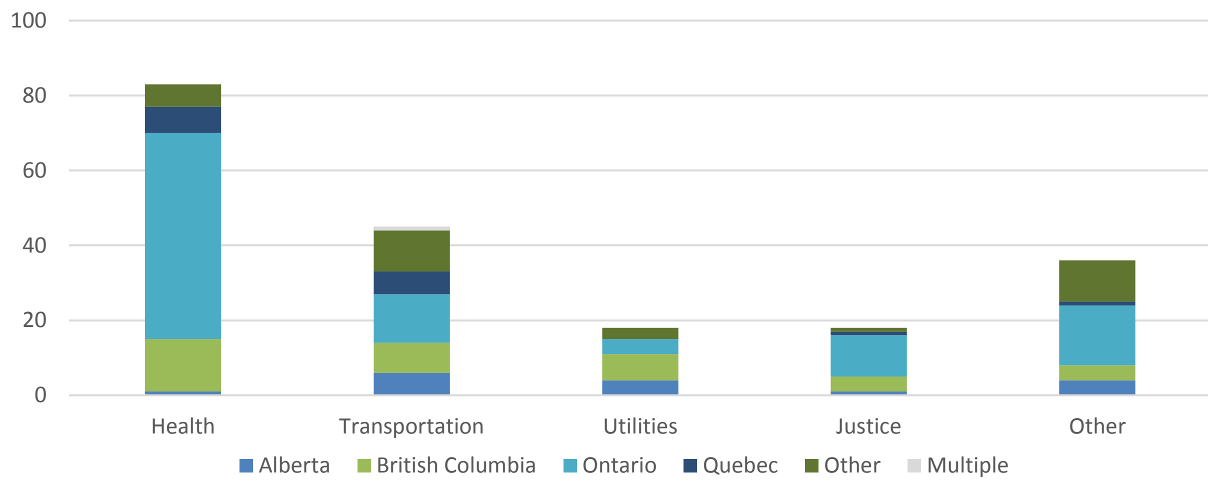
[13] Data in the CCPPP database is drawn from publicly available sources.

[14] Note that while Saskatchewan is bundled into "other" in our analysis for practical purposes, the Government of Saskatchewan has demonstrated a dedication to the P3 model and has developed a growing pipeline of projects to support their "Plan for Growth".

megaprojects, such as the Eglinton Crosstown LRT in Toronto, Ottawa LRT (Confederation Line), and Highway 407 ETR through the Greater Toronto Area.

These 200 projects form the basis for our analysis below. For a full list (by asset class and location) please see Appendix C.

Figure 1 Number of Canadian P3s, by asset class and location



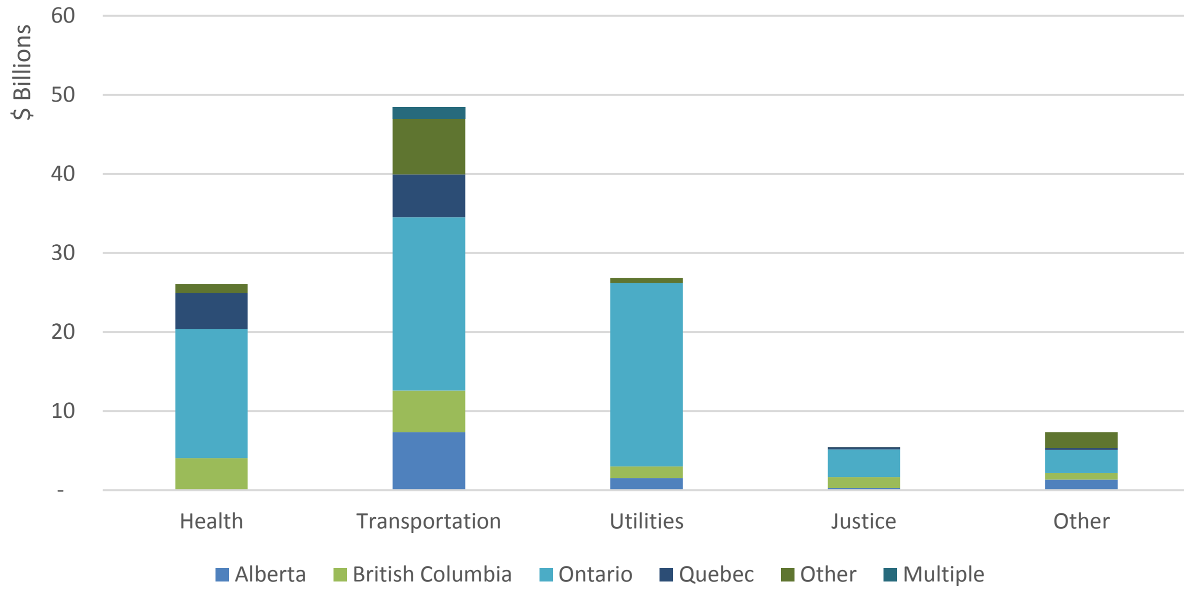
Source: Canadian Council for Public-Private Partnerships; calculations by CANCEA

Table 1 Number of Canadian P3s, by asset and location

	Health	Transport.	Utilities	Justice	Other	Total
Alberta	1	6	4	1	4	16
British Columbia	14	8	7	4	4	37
Ontario	55	13	4	11	16	99
Quebec	7	6	-	1	1	15
Other	6	11	3	1	11	32
Multiple	-	1	-	-	-	1
Total	83	45	18	18	36	200

Source: Canadian Council for Public-Private Partnerships; calculations by CANCEA

Figure 2 Agreement costs (nominal) of Canadian P3s, by asset class and location



Source: Canadian Council for Public-Private Partnerships; calculations by CANCEA
Note: Non-risk-adjusted agreement costs used where available

Table 2 Agreement costs (nominal) of Canadian P3s, by asset class and location ($ billions)

	Health	Transport.	Utilities	Justice	Other	Total
Alberta	0	7	2	0	1	10
British Columbia	4	5	1	1	1	13
Ontario	16	22	23	4	3	68
Quebec	5	5	-	0	0	10
Other	1	7	1	0	2	11
Multiple	-	2	-	-	-	2
Total	26	48	27	5	7	114

Source: Canadian Council for Public-Private Partnerships; calculations by CANCEA
Note: Non-risk-adjusted agreement costs used where available; numbers may not add due to rounding

3.0 COSTS AND BENEFITS OF P3S

3.1 Introduction

Given the incentives to maximize profits, there are real benefits (and some costs) to the use of P3s, and the following subsections highlight the ones typically discussed (though this list is not exhaustive). (One point to make is that P3s – certainly second wave projects – are relatively new and therefore relevant data is still too limited to support many conclusions definitively.) What this study hopes to show is that – beyond the benefits outlined in this section – there is economic value from delivering such assets for public use *sooner*, as productive infrastructure projects are not just about the type, size, and location of an asset, but when it is built. (For example, being years late on delivery of a wastewater system to a new subdivision means years without new resident workers.)

However, while some proponents of P3s suggest that the procurement method enables faster commute times or better health outcomes, it is important to note that these are features of well-maintained infrastructure assets themselves rather than the delivery method. Therefore such claims are not unique to the value of P3s. Similarly, many have claimed that P3s provide a new source of funding for infrastructure, particularly helpful in a period of fiscal restraint. However, this confuses the notion of financing (see Section 3.4 below) with funding – where, at least with ‘second wave’ projects, the latter is still a public responsibility. (A rough analogy would be that a credit card company temporarily finances purchases, but cardholders are still on the hook for paying for everything that they buy.) That is, P3s typically do not bring a new source of funding for infrastructure in Canada, and therefore do not directly help governments with the cost of building it.

3.2 Risk transfer

P3 projects typically entail risks for private consortia that they would not usually bear under traditional procurement. As discussed above, cost overruns and construction delays have plagued large-scale infrastructure projects. So, transferring some of the risk[15] of these to the private sector, in return for a ‘risk premium’ (i.e., a form of insurance payment), creates an incentive for the private sector to identify and manage project risks to their own capital (i.e., they have some ‘skin in the game’). This is different to the insurance that would be purchased for a house, which is generally priced according to things largely outside of the homeowner’s control (e.g., the weather or neighbourhood characteristics), because those executing the projects are able and incented to identify and manage the risks. The notion of an ‘optimal’ risk-sharing arrangement should be about aligning incentives such that those best suited to manage given risks can do so (de Bettignies and Ross 2004). The question then becomes "when should government buy this insurance, and if so, how much is necessary?" (T.D. Economics 2015).

[15] The risks typically transferred in Canadian P3s include construction and availability risk, but hardly ever include demand risk (Siemiatycki 2013).

Like any risk premium, the determination of the probabilities and costs of risk are largely assumption driven, but should be fair. That said, these risk premiums can be quite high – averaging 50% in some older cases – with little (at least public) evidence to support why (Siemiatycki and Farooqi 2012). However, P3 authorities have acknowledged the need to keep it down and have taken certain steps that should do so. These include higher screening thresholds (i.e., ensuring projects are large), risk workshops, and increasing substantial completion payments (lowering long-term financing costs). Further, some have argued[16] that because consortia compete in fair and open procurement processes and continue to become more experienced in managing these risks in the Canadian context, these premiums have and should continue to come down. Unfortunately, limited research or data have been published in this regard.

Further, risk exposure in P3 projects can be allocated in one of three ways (Iacobacci 2010):

1. Risks transferred fully to the private sector, such as construction defects
2. Risks retained by the public sector owner, such as delays due to environmental assessments
3. Risks shared by both parties, such as trade strikes

Practically, in nearly all cases of delay, the private consortium accepts at least partial responsibility (Hanscomb 2015).

3.3 Integration, innovation, and long-term planning

Traditional procurement of infrastructure has utilized the design-bid-build method, in which the public sector specifies (and puts to market) project specifications and a detailed design of the asset. Private organizations then bid on the opportunity to construct that asset, paid progressively by the public sector. While a stipulated price contract is generally used, cost overruns and timing delays often occur due to numerous risk factors, including design changes – which are likely as the teams used to design and construct the projects are generally segregated. Further, as the warranty periods are often short (e.g., one to three years), the public sector must bear the longer-term responsibility for the serviceability of the asset (Yuan and Zhang 2016). As such, the public sector then often also enters into *more* contracts for asset maintenance and operation (Iacobacci 2010).

In contrast, P3 projects often include *output*-based specifications that stipulate what service criteria the final asset must meet – with the decision on how to do so left up to the bidding consortia. This is because "the success of an infrastructure project should be measured on the standard of service enabled by the asset, rather than on the inputs alone" (Boothe, et al. 2015). This provides an ideal environment for bidders to propose innovative design and delivery solutions. However, there is still some uncertainty among P3 experts as to whether P3 projects actually provide innovative designs. One study suggested that innovation does occur in P3 projects in Ontario, "fuelled by competition and incentives, and a structure that facilitates collaboration between the private-sector firms delivering projects", leading to cost savings (Himmel 2015). Another study suggested that an 'innovation adjustment factor' of between 5% and 18% (i.e., a multiplier to be used in determining the value of using P3) be built into the business case for the use of P3 projects,

[16] For example, Michael Marasco (before the House of Commons Standing Committee on Government Operations and Estimates), see Hansard (2012)b.

depending on the model type (Altus Group 2015). However some experts have been "hesitant to fully endorse the concept that P3s are in their nature innovative, as measurement difficulties prevented such a wholehearted endorsement" (Gill and Dimick 2013).

Finally, one large (likely) benefit of many P3s – specifically those including a maintenance component – is the enshrining of effective life-cycle planning and asset management, often missing in publically-stewarded assets. When the consortium designing and building an asset is also responsible for its long-term upkeep, there is an incentive to design and construct the asset well in the first place and then take regular preventative actions over the life of the asset. In other words, "if the private partner is not accountable in any way for the long-term maintenance of the facility, it does not have much incentive to 'build it to last'" (Gill and Dimick 2013). However, given that virtually no P3 projects with maintenance components included have reached the end of their contract term, there is not yet sufficient data to fully substantiate this proposition.

3.4 Financing and transaction costs

As already discussed, P3 projects are financed (wholly or partially) by the private sector at the borrowing rates available to them, but ultimately paid for by the public sector. One of the key differences from traditional procurement is that public-sector payments are held back until the point that the project is 'substantially completed'. Further, in projects where maintenance (or operating) components are included, payments for those pieces are delivered through regular service payments over the (often decades-long) contract period.[17]

Most commenters on P3s highlight that the (posted) borrowing rates for the private sector are higher than those of the government. The argument goes that, because the government can tax (or print more money, in the case of the federal government), there is inherently less risk in lending to relatively stable governments with essentially guaranteed sources of revenue[18]. This might be viewed as an inherent cost imposed on the use of P3s. However, there are a few subtle but key points on risk-pricing here.

First, P3s are a means of transferring risk to the market (which comes with a price). The private financing of P3s is part of this process and can be seen as a benefit, with some arguing that the "additional level of oversight imposed by a private lender that instilled further discipline and good governance in the project" is a worthy cost (Gill and Dimick 2013). That is, lenders both encourage greater upfront due diligence on the ability of private organizations to deliver and adequately provision for design, execution, and operational defects (where relevant), and monitor projects for credit events as they proceed. Further, as lenders claim precedence on payments from the public sector over consortia equity holders, the consortia is financially incented itself to ensure project delivery.

[17] This excludes the rare Canadian cases where revenue (e.g., road tolls) is included in the agreement.

[18] It should be noted that some governments around the world, particularly those in less-developed countries, might use P3s because there are advantages to isolating project financing from issues limiting government-issued debt (e.g., political instability or corruption). Further, the use of P3s can supplement governments where the expertise or capacity to execute large and complex projects does not exist 'in-house'.

Second, as has been argued by others, this financing cost comparison is unfair, as it "ignores the costs resulting from government authority to levy, when required, additional fees and taxes to repay lenders if one or several funded projects prove unprofitable" (Chen and Chiu 2013). While lenders price government default risk lower than private organizations, it does not change the fact that the funds are used to undertake the same activity with similar risks, prices, and inputs. This is because government can effectively hide its *unmeasured* risk premium when the taxpayer acts as the (unknowing) insurance company. In effect, then, a P3 risk premium is more akin to a 'political risk' premium paid by government, as it is able to transfer responsibility for overruns and delays, and therefore avoid having to explain higher costs to the public. Further, private organizations can deduct interest, lowering their tax burden (de Bettignies and Ross 2004), thus passing some of the cost of default risk premium back to government.

Given these reasons, the identified 'cost' difference of financing is clearly not one of *value*. The expectation is that as the market for P3 matures in Canada, P3 consortia will be able to demonstrate stable results and further expertise in their ability to price the risks that governments pay under contract, such that lenders will likely start to consider loans to P3 consortia as 'government-backed' (T.D. Economics 2015) and reduce the spread in borrowing rates.

Research also points to the higher transaction costs of P3 projects (e.g., legal, project management) stemming from the complexity of such projects (e.g., the number of companies involved in consortia). But like many issues with comparison between P3 and traditional procurement, a lack of data related to government processes makes it a very difficult assessment. Additionally, there is also a mismatch in timing which gives the topic more profile as "many of the planning and management costs that occur at later stages under a conventional procurement approach are necessarily incurred upfront in a long-term P3 agreement" (Iacobacci 2010).

3.5 Bringing these all together: Value for money

Most of these factors are quantified in value-for-money (VfM) assessments, often undertaken by specialist consultants on behalf of P3 authorities (including agencies, ministries, and municipalities) in advance of the decision to proceed with a P3. These assessments often involve risk 'workshops' which include stakeholders and subject-matter experts to help calculate the risk-adjusted costs of delivering a project using P3 versus a 'public-sector comparator' (PSC) – essentially the same project if delivered traditionally. In cases where the benefits outweigh the costs, the recommendation to proceed with a P3 model is made.

It is important to note that in the discussion of procurement methods, *value does not equal cost*. P3 projects are rarely the cheapest option if only considering the base construction, financing, and operation and transaction costs. For example, Siemiatycki and Farooqi (2012) reviewed official *ex ante* VfM studies (i.e., estimates of value made before construction) commissioned by governments or their agencies across Canada. They showed that the base costs of the PSC could be around 30% cheaper. However, when the full range of risks are incorporated, the business case for delivery via P3 becomes much clearer (Boothe, et al. 2015). That is, on a risk-adjusted basis, P3s provide more value. Iacobacci (2010) stated that "our review of the available VfM studies and guidance documents suggests that each of the four jurisdictions under consideration [Ontario, Quebec, Alberta, and British Columbia] have developed a rigorous methodology for comparing the costs of P3s and traditional procurements.”

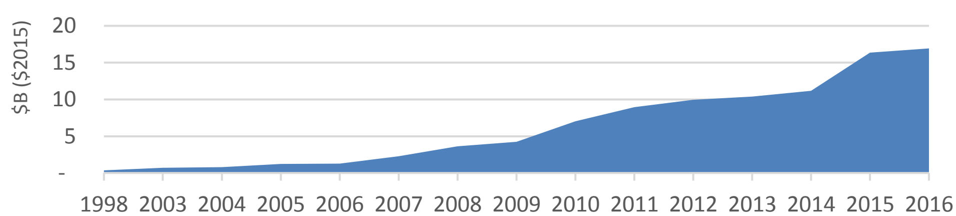
However, there is still considerable debate as to whether VfM is objective enough, given that it is an *ex ante* assessment of risks that can be difficult to quantify. Part of the concern around VfM seems to stem from a lack of transparency: several witnesses to the House of Commons Standing Committee on Government Operations recommended that more information behind the VfM estimates be verified publically by independent parties and based on empirical evidence (Hansard 2012).

That said, the P3 method has been highly scrutinized (arguably more so than traditional procurement methods) – including by numerous Auditors General – which has led to multiple reviews of VfM methodologies across the country. For example, in 2014, Infrastructure Ontario undertook an internal process to update and refine the methodology. Similarly, in 2014, a B.C. government review concluded that “Partnerships BC has designed a robust process to help assess value for money of public private partnership (P3) capital projects.”[19] Further, VfM is the standard assessment practice across the world – the Organization for Economic Co-operation and Development (OECD) found that, of 20 countries surveyed, 19 used an *ex ante* process to ascertain value for money (Burger and Hawkesworth 2011).

In total, the 136 projects for which value-for-money (VfM) data were available have a cumulative VfM of almost $17 billion ($2015).

Of the 200 Canadian projects being investigated, 136 have VFM assessments available (virtually all since the mid-2000s). In 2015 dollars[20], value savings from these projects range from $2.5 million to $2.2 billion. Nearly two-thirds of these savings come from the transportation sector and another quarter from the healthcare sector. As a percentage of the respective public sector comparators (130 available), this represents a range of 1% to 61% in potential value, with a weighted average of 24%. (Note that this is only for projects that went ahead using P3, and so by definition had a positive VfM. Therefore, this statement does not imply that *all projects* would deliver 24% in value for money via a P3. It is simply a statistic of those that have been procured via a P3.) As **Figure 3** shows, the cumulative VfM of these projects has reached almost $17 billion ($2015).

Figure 3 Cumulative Value for Money (VfM) of 136 Canadian P3 Projects (2015$B)



Source: Canadian Council for Public-Private Partnerships; calculations by CANCEA

[19] See: BC Gov News (2014).
[20] Using Statistics Canada’s non-residential building construction price index (Table 327-0043).

4.0 ECONOMIC IMPACTS OF CANADIAN P3 PROJECTS

The economic benefits of infrastructure investment extend beyond the direct stimulus effects captured by traditional input/output analyses. The stock of infrastructure in the economy provides the support for all industries to operate. Without sufficient infrastructure, companies suffer from lower productivity due to greater input costs and frictions ranging from the cost of goods to wages to the ability of companies to attract and retain skilled employees.

This section provides the economic impacts of the 200 Canadian P3s being evaluated. Because P3s are simply a delivery mechanism for (generally large-scale) public infrastructure assets, these results would largely apply regardless of the procurement method used. However, this assumes that the projects would have actually *moved ahead* (or even simply have been delivered on time) regardless of the procurement method used. Therefore, Section 5.0 will show that there is an economic benefit of delivering such projects on time.

4.1 Methodology

Traditionally, a variety of economic models have been used to analyze the impact of infrastructure investment. These include cost functions, production functions, and growth accounting (Antunes, Beckman and Johnson 2010). Such approaches would suffice if only direct (i.e., construction), indirect (i.e., their suppliers), and the follow-on induced economic effects (i.e., workers go buy groceries) of building infrastructure were relevant. However, the economic impact of an infrastructure asset being *used* can go well beyond the economic impact of *building* it. Such effects are called 'system effects' (see Smetanin and Yusuf (2016)) which include variables not traditionally examined under the economic lens, such as 'productivity coupling' and consequent impacts upon asset values.

While productivity coupling is inherently consistent with the input/output approaches that underlie the quantification of the usual direct, indirect, and induced effects of building infrastructures assets, it extends the scope of the impacts through the use of the infrastructure assets by considering:

- The direct consumption of public infrastructure by industry as an input to production of goods and services, as well as their transportation – as used in traditional economics (input/output matrices) – that is key to the calculation of direct, indirect and induced effects of infrastructure investment;
- The indirect consumption of public infrastructure by industry and governments in the movement of their employees; and

> The economic impact of an infrastructure asset being ***used*** can go well beyond the economic impact of ***building*** it. Such effects are called 'system effects', and include variables not traditionally examined, such as 'productivity coupling' and consequent impacts upon asset values.

- The indirect consumption of public infrastructure by industry and governments in the health and skills development of their employees (current and future).

A broader productivity coupling of public infrastructure with production activities exists when infrastructure is a constraint on production.[21] That is, when public infrastructure is regionally insufficient, current and future production that can occur in that region is constrained. It is the indirect consumption of public infrastructure by industry, households and governments that is a key component of the 'systems effects' alluded to.

Additional systems effects occur as asset values may change with public infrastructure investment, which can have consequent impacts upon household, industry and government investment, debt and private migration choices. For example, the value of homes near a new transit stop increase in many cases. This value proposition is particularly evident in the presence of existing public infrastructure deficits and a growing population.

Such systems effects require the identification and accounting of both financial (e.g., realized input and output, investment/debt decisions) and non-financial events (e.g., expected demand, expected supply, policy and planning choices, activity location choices). Additionally, the fact that households, industries and governments have to compete with each other under their own unique budget constraints (e.g., income, expenses, assets, ability to borrow) adds an additional layer of complexity which must all be reconciled in order to construct and simulate an internally-conserved, consistent, and cohesive system.

In order to simultaneously account for many of the economic and productive impacts generated as a result of regional public infrastructure investment and the unique constraints on the economic players as they compete, agent-based modeling is employed. The ability to measure and understand such outcomes and manage the computational complexity required is at the heart of CANCEA's systems-based platform, *Prosperity at Risk* (PaR). Appendix A includes a stepwise walk-through of the PaR approach with more details.

4.2 Economic value of grouped Canadian P3 projects

The impact of infrastructure investment is felt across all sectors of the economy including private industry, governments, and households. By using a complete model of the Canadian economy, we are able to present an internally consistent set of outcomes including:

- Gross domestic product
- Federal and provincial tax revenue
- Private capital investment
- Employment wages

[21] This conforms to the roots of 'stock-flow consistent' economic models: see Macedo e Silva, A., Dos Santos, C. H., 2008. *The Keynesian Roots of Stock-flow Consistent Macroeconomic Models*. Levy Institute of Economics of Bard College, Working Paper no. 537.

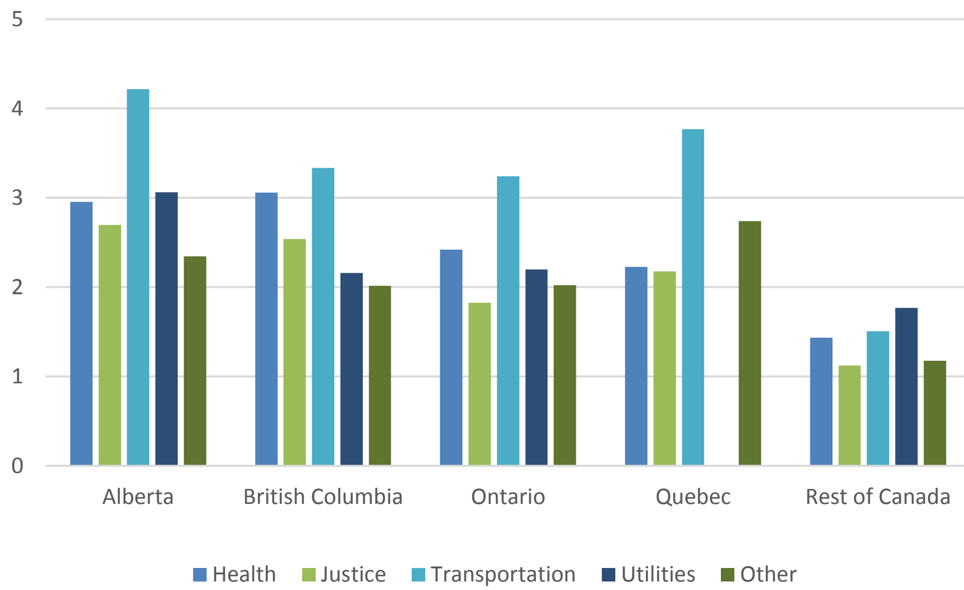
The 200 Canadian P3 projects studied were divided into five asset classes (health, transportation, utilities, justice, and other) and grouped by location within the four largest provinces and the rest of Canada for a total of 25 groups of projects. (Quebec saw no P3 projects in the utilities sector and there is one multi-province project.) **Table 1** in section 2.1 summarizes the number of projects in each category, with a full list provided in Appendix C.

The economic significance of each group was estimated by *removing* the specific, individual sets of investments from history and examining the changes in how the economy evolved with the lower stock of infrastructure.[22] It is important to note that the systemic economic impacts of infrastructure investment are not symmetric with respect to the addition or removal of an investment. For example, if an economy has close to the 'optimal' stock of infrastructure (i.e., little or no infrastructure deficit), the benefits of additional investments to increase the quantity or quality of infrastructure stock would be largely dominated by the stimulus effects (i.e., direct, indirect and induced). That is, the majority of economic impacts would simply come from paying people to build the asset, and the systemic effects would be smaller. However, if the quality or quantity of infrastructure stock is reduced through the removal of significant infrastructure investment, the entire economy could be affected. Therefore, to capture the true value of an infrastructure investment that has been made, it is best to compare it to the case where it had not been made. For each group of investments, the cumulative economic benefits were estimated by simulating 30 years from the first investment in each group. In the few cases where the investments in a group exceeded the 30 year time frame, the investment made up to the 30 year point was used to calculate the benefits.

[22] Note: these effects propagate across the Canadian (and, in fact, world) economy, though are largely localized. For example, a port expansion project in British Columbia affects the economy of southern Ontario and vice versa, but in different ways. This is why systems thinking is crucial to such evaluation, as it picks up unintended and typically unmeasured impacts.

Figure 4 (see Appendix D for table versions of the following results) presents the estimates of the economic activity that each group of infrastructure investment *individually* supports through both stimulus and systemic activities. The variability across the different regions and groups arise from the differences in infrastructure stock and dependent industries across the country. As the various infrastructure groups presented in **Table 1** have considerably different total investment, the results are normalized using the total investment of each group.

Figure 4 Impact on GDP ($) per dollar invested

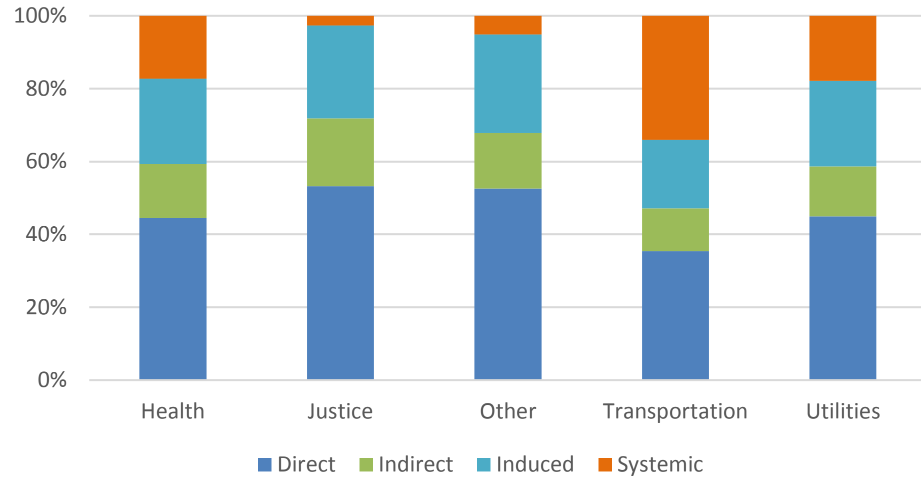


Across the country, each dollar invested in the P3 project groups supported between $1.1 and $4.2 of economic activity.

Across the country, each dollar invested in the individual P3 project groups has supported between $1.1 and $4.2 of economic activity.[23] (Note that these numbers are not additive.) Assuming the money spent on the investment would not be spent or distributed otherwise, the first dollar of the benefit is due to the direct impact (i.e., the money has been injected into the economy to the project contractor). To support the execution of the project, secondary suppliers must provide goods and services to the primary contractors. This results in indirect economic benefits to the economy. Additional wages and profits earned through direct and indirect economic activities can induce further spending in the economy by households (e.g., these people go and buy groceries) and industry (e.g., capital investments) resulting in a third contribution to the benefit. Finally, a larger stock of quality infrastructure supports greater economic activity resulting in systemic benefits not directly related to the investment itself. **Figure 5** presents the split of these benefits by group.[24]

[23] InterVISTAS (2014) found Canadian P3s supported about $1.8 of economic output per dollar of project value.
[24] InterVISTAS (2014) found that the split of direct/indirect/induced economic output impacts of Canadian P3s were roughly 55%/25%/20%.

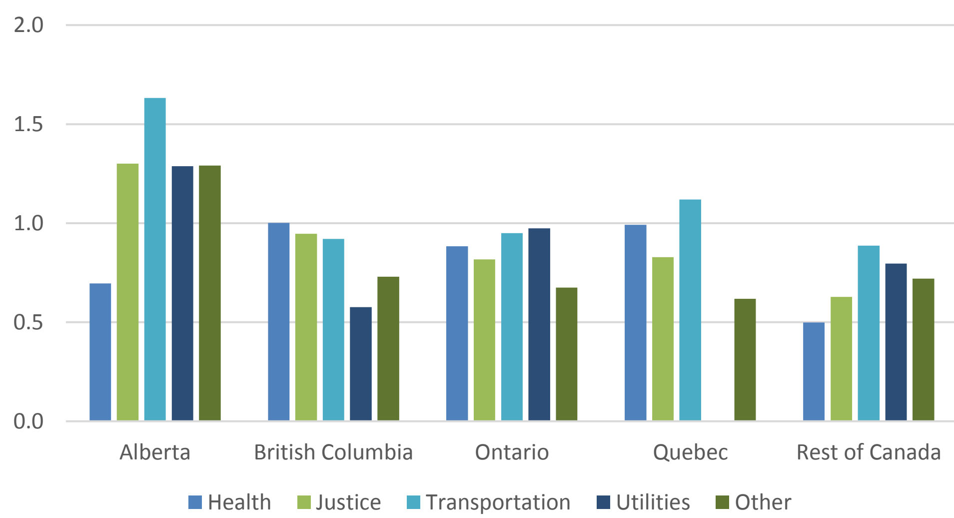
Figure 5 Contributions of direct, indirect, induced, and systemic impacts to GDP



It is interesting to note how the systemic contributions vary across infrastructure categories, with transportation, utilities, and health investments having the largest systemic impacts. Justice-related infrastructure on the other hand has a relatively small systemic contribution, suggesting asset portfolios that were closer to the optimal size (though not necessarily quality) or that the investments were not large enough to have a significant portfolio effect.

In addition to public infrastructure, a key component supporting economic activity is capital investment by the private sector into buildings, engineering, and machinery and equipment. **Figure 6** presents the additional private capital investment supported by each of the P3 investment groups. (Note that the categories refer to the P3 investment groups, not the type of private capital investments made.) The locational differences arise from the current state of private capital investment and the mix of industries and their infrastructure dependencies.

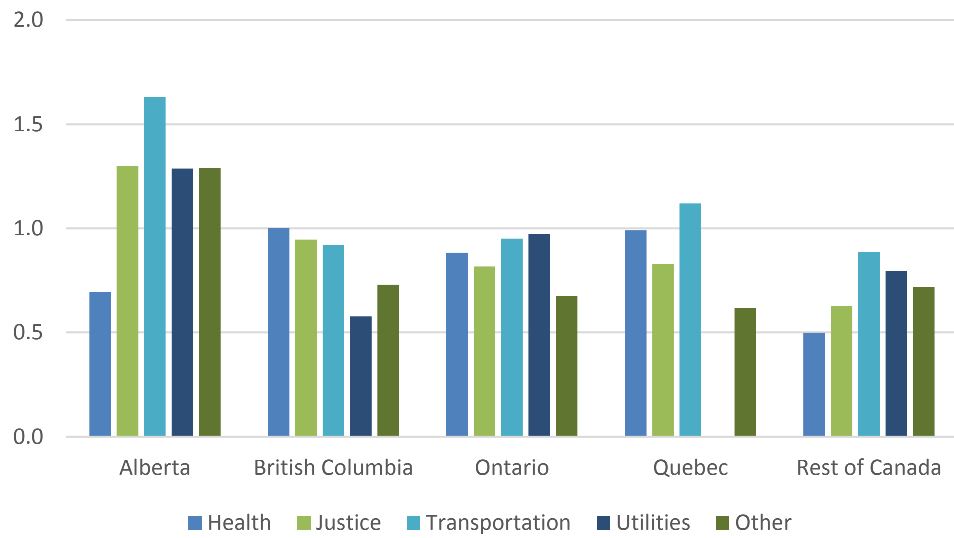
Figure 6 Impact on private capital investment ($) per dollar invested



In general, for each dollar invested in quality infrastructure projects for each of the project groups, between $0.5 and $1.6 of private capital investment is supported. (Again, these numbers are not additive.)

In combination with private capital, industries generally require new employees to support additional economic activity. **Figure 7** highlights the impacts on total wages (a combination of both increased employment and higher individual wages).

Figure 7 Impact on total wages ($) per dollar invested

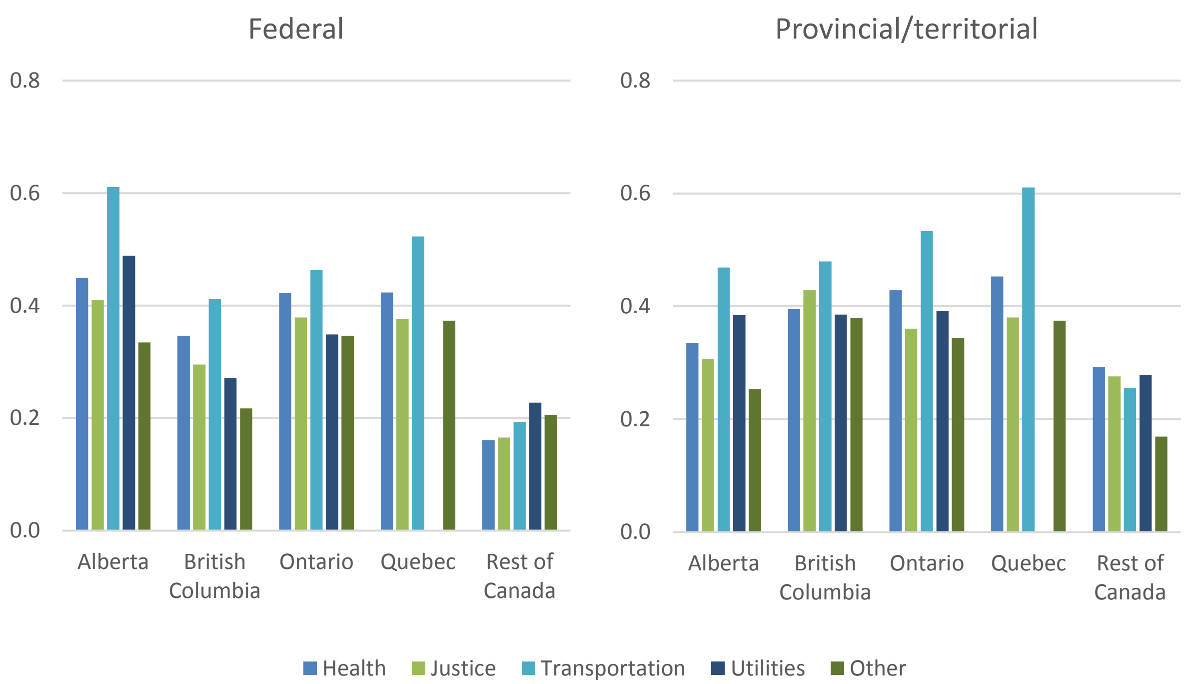


These values range from about $0.5 to $1.9 of additional wages per dollar invested.[25] Again, values in the transportation sector and Alberta were generally higher for reasons discussed above.

[25] InterVISTAS (2014) found Canadian P3s supported about $0.6 of wages and benefits per dollar of project value.

Finally, the additional economic activity results in greater tax revenue for governments through increased personal income taxes, corporate taxes, and consumption taxes for each of the provinces/territories and the federal government. **Figure 8** highlights these impacts, which range from $0.4 to $1.1 in combined federal/provincial tax revenue per dollar invested. For larger projects in infrastructure types which are more critical to support economic activity, such as those in the transportation categories, the long-term tax revenue generated by the supported economic activity can exceed the cost of the investment. While other asset categories such as health and justice have smaller tax revenue benefits, it is important to note that they contribute to greater quality of life and can help attract and maintain private industry investment and labour.

Figure 8 Impact on total tax revenue ($) per dollar invested



Combining both the federal and provincial/territorial tax revenue impacts, slightly over half of the additional tax revenue arises from consumption taxes driven by the induced and systemic benefits. 30% of the remaining benefit arise from corporate taxes with the remainder from personal income taxes. [26]

In addition, these benefits of the P3 projects arise from the utility of the assets and are complementary to the VfM returns highlighted in section 3.5, and again come from the building of the asset, regardless of procurement method.

[26] InterVISTAS (2014) found Canadian P3s supported about $0.1 of income tax revenue per dollar of project value.

4.3 Economic value of all Canadian P3s projects as a portfolio

Note that these impacts are not as large as those found in Smetanin and Stiff (2015) due to the different size of infrastructure being investigated. In that report, a total of $130 billion of future infrastructure investment (across many types in Ontario) was deferred in a single scenario. In the current analysis, the largest group is the Ontario transportation P3s, which have a total adjusted agreement cost of slightly over $14 billion. As a result, the economic consequences of deferring the infrastructure investment is much greater in the first case than in the current analysis. However, if the entire group of P3 projects were considered as a single portfolio, the economic impact would be much greater, even when normalized to a per dollar impact.

Taken together as a portfolio – that is, evaluating the impact of not having undertaken *any* of the 200 projects rather than investigating by type-province groupings individually – the overall GDP impacts grow from a group-wise average of $2.4 per dollar invested to $3.6 per dollar invested.[27] In other words, the total economic value of these projects is more than the sum of their parts. (This should make intuitive sense – adding a transit line to an economy with existing schools and hospitals should have a lower per dollar impact than adding a transit line along with a school and a hospital.) Further, the systemic benefits in this scenario quickly increase to about half of the overall GDP impact because the economy has benefited from a broad portfolio of assets across the country.

Taken together as a portfolio – that is, evaluating the impact of not having undertaken any of the 200 projects – the overall GDP impacts grow from a group-wise average of $2.4 per dollar invested to $3.6 per dollar invested.

The total economic value of these projects is more than the sum of their parts.

[27] This is itself much smaller than in Smetanin and Stiff (2015), largely because that study investigated a larger impact on Ontario only.

5.0 SENSITIVITY ANALYSIS OF TIMING CERTAINTY

While section 4.0 provides the economic impacts of the grouped projects themselves, this section aims to provide evidence of something else: the economic impact of delivering any project via P3 versus traditional procurement. Again, because P3s are simply a delivery mechanism for (generally large-scale) public infrastructure assets, the results above would have largely applied regardless of the procurement method used. However, this assumes that the projects would have actually *moved ahead* (or even simply have been delivered on time) regardless of the procurement method used. So the discussion around Canadian P3s is really about the costs and benefits of delivering infrastructure in a non-traditional way.

Previous CANCEA research has highlighted that the building of infrastructure itself is important, but misses the value of the asset itself, if it is built at the right scale, in the right place, and at the right time (Smetanin and Stiff 2015). (This is seen again in section 4.3 by the noticeable systemic impacts.) If procurement stands in the way of delivering or enabling a vital public service at that time, then the economy suffers. By evaluating the economic importance of such timing certainty, this paper adds a new perspective to the debate about the use of P3s.

5.1 Is there a difference in timing?

The most fundamental question in this regard is whether there is a timing difference between the two methods of delivery.

Numerous studies and agency reports have agreed that once a contract is signed, P3 projects tend to be delivered on time whereas (at least large and therefore comparable) traditional projects do not. For example, Infrastructure Ontario's 2015 annual "Track Record Report" (Hanscomb 2015) stated that 33 of the 45 (or 73%) projects that reached substantial completion were completed on time or within one month of schedule. A similar review of UK P3 projects had a similar result of 69% (National Audit Office 2009). Similarly, research from the U.S. shows large P3 highway projects come in at 0.3% ahead of schedule on average (Shrestha 2007) while research from the U.K. shows P3 projects come in 1% ahead of schedule overall, and 16% ahead for 'standard' buildings (Mott McDonald 2002).

However, these analyses usually ignore the *pre*-contract time spent on planning and procurement that is typically much longer for P3s. While this longer lead time likely means better due diligence – that is, the projects are 'well developed' (Duffield 2008) – it makes the comparison unfair overall. Claims that P3 projects are delivered on time, while true from a given starting point, do not provide the whole picture. (That said, there are certainly benefits to the public in terms of less construction inconvenience (T.D. Economics 2015) and to agencies that need to undertake large-scale planning to move staff and equipment into a new facility.) Put another way, traditional projects get a 'head start' on P3s, which are further slowed early on by additional scrutiny.

As such, and as is highlighted in **Table 3** below, a number of studies from Australia have attempted to get a better handle on the full timing comparison. Unfortunately, there is no easily available data for such a comparison in Canada. Further, "translating such results to other jurisdictions is a highly speculative exercise, due to differences in procurement processes, market conditions, and regulations, to mention just three of the myriad potential factors that could yield different results" (Iacobacci 2010).

To combat this concern, we will present a full suite of sensitivity analysis and try to locate the approximate situation of Canada relative to an 'optimal' state.

5.2 'Optimism bias'

Mott McDonald (2002) introduced the notion of an 'optimism bias', which is simply the percent difference between an expected value and the actual result, and comes from not fully incorporating all the risks involved. So if, for example, a project was expected to take twenty months to complete, but actually took 24, then the optimism bias would be 20% – or $100 * \frac{(24-20)}{20}$.

Table 3 summarizes a number of studies that investigate optimism bias across the range of project delivery types. We borrow from Mott McDonald (2007) the notion of delivery 'stages' where:

- Stage 1: time between original announcement of a project and contractual commitment (the 'gestation period')
- Stage 2: time between contractual commitment and completion (i.e., construction).

As just discussed, many studies and agency reports focus solely on stage 2, where P3s typically see much lower optimism biases than their traditional counterparts. One thing that is not entirely clear is how much of this bias is due to actual optimism (i.e., that planners think a project should go smoothly) versus it being a measure of poor project management performance. Notionally, however, a persistent bias is an indication of a certain behaviour. As discussed in Section 3.4, private consortia must account on their balance sheet for the risk of not delivering, meaning it is in their financial interest to deliver on time. On the flip side, government planners are not faced with such an incentive to 'get it right', and so are 'allowed' to let problems arise and be dealt with later. That would suggest that the 'gestation period' for traditional projects should be theoretically shorter, with potentially longer construction phases. Overall project management performance includes both of these combined.

Utilizing studies from Australia that investigate 'optimism bias' (the percent difference between an expected value and the actual result), we find that, as advertised, P3 projects are most effective for large, complex projects, but not necessarily for smaller, more straight-forward ones.

What **Table 3** shows is that:

1. As discussed, once a contract is signed, and the project enters its construction stage, P3s significantly outperform traditional projects in delivering on time, both in terms of average

optimism bias – ranging from -1% to 3% overall for P3s versus 4%-26%[28] – and in terms of certainty (i.e., less variability).
2. Over the full cycle of a project, there is little difference between P3s and traditional projects overall, although there is more certainty (i.e., less variability) in P3s.
3. When accounting for project size, P3s again outperform, with Duffield and Raisbeck (2007) estimating a 'value-weighted optimism bias' of 13% for P3s versus 26% for large traditional projects. In context, this difference would mean an average *additional* delay of one year on an eight year-long project procured traditionally.
4. Further, Mott McDonald (2002) suggests that the more complex a project is, the more likely that a P3 will deliver on time.

These results suggest that, as advertised, P3 projects are most effective for large, complex projects, but not necessarily for smaller, more straight-forward ones.

[28] If only larger projects are also considered, the range becomes 17%-26%.

Table 3 Summary 'Optimism Bias' Statistics on Timing Differences from Various Studies

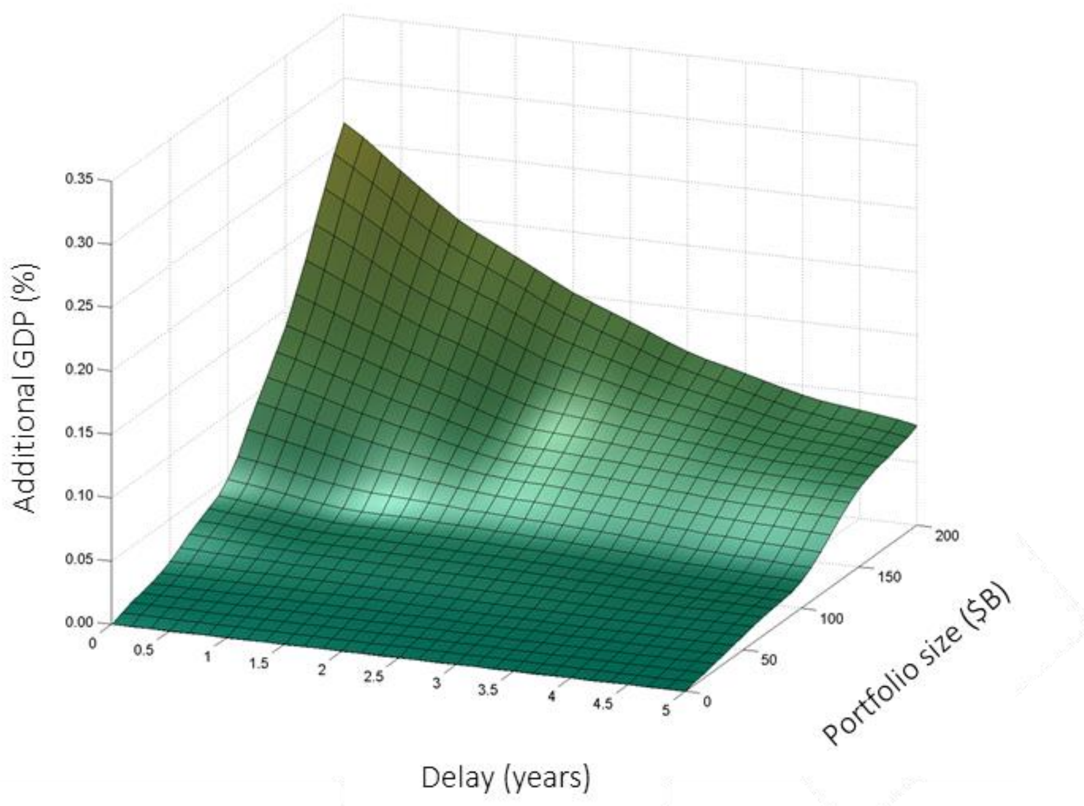
Study	Time Duration 'Optimism bias'					
	Full (Inception - Operational)		'Gestation' (inception - contract)		Construction (contract - operational)	
	Traditional	P3	Traditional	P3	Traditional	P3
(Mott McDonald 2002): 50 projects (UK)					Non-std. bldg.: 2-39% Standard bldg.: 1-4% Non-standard Civ. Eng.: 3-25% Standard Civ. Eng.: 1-20% Equipment: 10-54% All: 17%	Standard bldg.: -16% Equipment: 28% All: -1%
(National Audit Office 2003): 37 projects (UK)					70% delivered late	24% delivered late
(Pollock and al. 2005): 67 projects (Aus)	17%	15%	-4%	15%	19%	2.6%
(Duffield and Raisbeck 2007): 54 projects (Aus)	18% 'Value-weighted': 26%	10% 'Value-weighted': 13%	Stage 1: 12% 'Value-weighted': 29% Stage 2: 12% 'Value-weighted': 9%	Stage 1: 24% 'Value-weighted': 13% Stage 2: 12% 'Value-weighted': 17%	4% 'Value-weighted': 24%	3% 'Value-weighted': -3%
(Duffield 2008): 67 projects (Aus)	Average: 15% Median: 11% St.Dev.: 45%	Average: 17% Median: 6% St.Dev.: 23%	Avg. Stage 1: -4% Med. Stage 1: 0% St.Dev. Stage 1: 27% Avg.Stage 2: 18% Med.Stage 2: 4% St.Dev. Stage 2: 25%	Avg.Stage 1: 15% Med.Stage 1: 0% St.Dev. Stage 1: 26% Avg.Stage 2: 12% Med.Stage 2: 9% St.Dev. Stage 2: 23%	Average: 26% Median: 7% St.Dev.: 42%	Average: 1% Median: 0% St.Dev.: 20%

Note: 'Value-weighted' in (Duffield 2008) adjusts for the contract size.

5.3 The economic value of delay

To estimate the full impact of delays of large infrastructure projects on the Canadian economy, a full sensitivity analysis was undertaken examining the impact of delays ranging from 0 to 5 years with P3 investment ranging from 0 to double the total of all P3 investments included in this analysis. The share of investments groups is kept the same as the share in the 200 P3 projects included in the analysis. **Figure 9** illustrates the value of infrastructure projects to the Canadian economy, measured in terms of the growth of the Canadian economy over 30 years, with varying sizes of infrastructure projects and delays to starting the project.

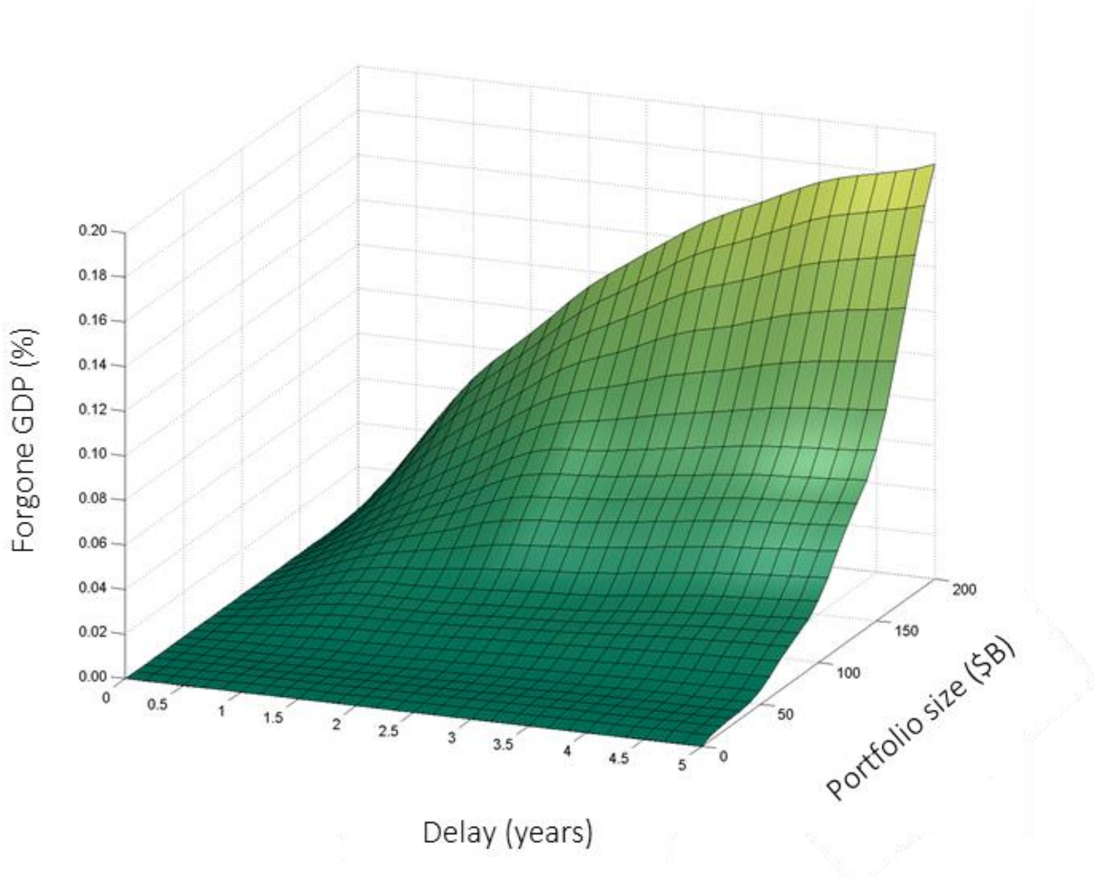
Figure 9 Value of investment to 30-year GDP growth, depending on project size and delays



Since infrastructure plays a critical role in the efficient operation of the economy, the effect of delays today compound over the next 30 years. As a result, the effective present-day value of an infrastructure project is reduced significantly for larger projects and greater delay in implementation.

As shown in **Figure 10**, for projects of a given size, the impact on Canadian economic activity increases quickly as the length of delay increases. Similarly, for a given delay, the impact on GDP increases with project size. That is, for smaller projects, the impact of delays even up to a few years has a relatively small effect, but as the projects grow in size the cost of delays to the Canadian economy quickly become more significant.

Figure 10 Impact of delay on GDP (forgone over 30 years)



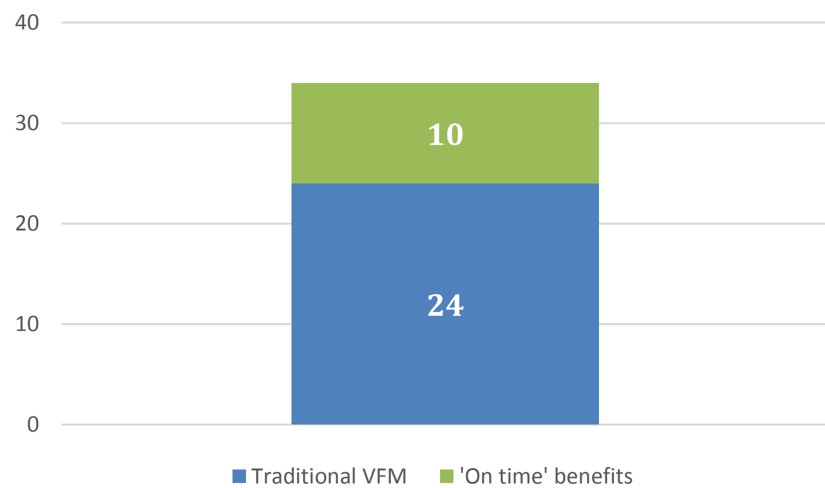
Note that the benefits apply to both large individual projects and portfolios of smaller projects of equal value. While the majority of individual P3 projects completed or underway in Canada are not 'megaprojects' (i.e., their adjusted agreement costs are less than $1 billion), taken as a single portfolio, the total adjustment agreement exceeds $100 billion putting it in the magnitude where delays start to have a significant impact. If the size of infrastructure projects continue to grow, the impact of delays in implementation of quality infrastructure projects to the Canadian economy will become increasingly significant.

Putting this into the Canadian context, of the 200 projects studied, 129 were operational and had sufficient data on the timing of the entire procurement and construction periods. By this measure, P3s typically take 6 years on average to deliver. When factoring in at least another year or two to get to the procurement stage from inception, we get that the delay avoided by using P3s is somewhere around 1-year on average (8 year project * 12.4% timing improvement as discussed above in section 5.2).

Taken together, a one-year delay for a portfolio of $100 billion reduces its 30 year value by the equivalent of nearly 10% of the total project value. As the portfolio increases in size, the cost of delays increase faster than the value of the projects. For example, for a portfolio 50% larger (i.e., worth $150 billion), the economic cost of a one year delay increases by 65% to almost 16% of the project's total value – that is, we start to move up the slope of **Figure 10**. To put this into context, these economic impacts are of a similar magnitude as the aggregate value-for-money for these projects. This means that as the portfolio of P3 projects continues to grow (which the relatively significant pipeline of projects[29] and planned public infrastructure investment would suggest), this value will continue to accumulate.

Taken together, a one-year delay for a portfolio of $100 billion reduces its 30 year value by the equivalent of nearly 10% of the total project value. These impacts are of a similar magnitude as the aggregate value-for-money for these projects.

Figure 11 Notional value-add to portfolio of projects worth $100 billion procured via P3 ($ billions)



[29] Examples of P3 projects not yet under construction: George Massey Tunnel Replacement (BC – transportation); Royal Columbian Hospital Redevelopment Project (BC – health); the Regina Bypass Project (SK – transportation); Saskatchewan Hospital North Battleford (SK – health); Seneca College King Campus Expansion (ON – post-secondary education); LRT lines in Toronto (Finch West), Ottawa (Confederation), and Waterloo (ON – transportation); Highway 427 Expansion (ON – transportation); New Toronto Courthouse (ON – justice); and the Macdonald Block Reconstruction Project (ON – government offices).

6.0 CONCLUSIONS

P3s are not a panacea, but research does show that for larger, more complex projects, P3s do provide value as advertised.

The economic impacts of the 200 Canadian P3 investments investigated (grouped by asset class and location) are significant, ranging from $1.1 to $4.2 (with a weighted average of $2.4) in GDP supported per dollar invested. Taken as a portfolio, these projects have supported significant economic activity – $3.6 in GDP per dollar invested. In other words, the total economic value of these projects is more than the sum of their parts, showcasing the systemic benefits of a larger portfolio of quality public infrastructure. However, these benefits would have occurred regardless of the procurement method *if built on the same schedule*.

The real economic benefits of P3s come from two places. The first is the now traditional VfM – that is, in the sharing (and therefore effective management) of risks between the private and public sectors. Looking at projects that went ahead as P3s where VfM assessments are public, value-for-money represents a weighted average of 24% of the respective public sector comparators.

The second area of value – which this report is the first to quantify – is in the economic value of reduced delays – that is, getting assets on the ground faster. Completing a typical $100 billion infrastructure portfolio one year sooner would mean an additional 10% of project value. This economic boost is of a similar magnitude as value-for-money. This proves that much of the (previously unquantified) benefit of P3s are in the delivery of large and complex projects on time.

If these additional values (VfM and on-time delivery) applied to the portfolio of 200 P3 projects studied, the potential value add would be upwards of $38 billion.

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APPENDIX A. AGENT-BASED MODELING

A.1. Agent-Based Modeling for Evaluation of Infrastructure Investment

Traditionally, a variety of models have been used to analyze the impact of infrastructure investment. These include cost functions, production functions, and growth accounting (Antunes, Beckman and Johnson 2010). General equilibrium macroeconomic models would suffice if only direct, indirect, and the follow-on induced economic effects of infrastructure investment were relevant. However, there are 'system effects', which transcend these because they include variables that are not traditionally examined under the economic lens, such as productivity coupling and consequent impacts upon asset values.

Productivity coupling refers to:

- The direct consumption of public infrastructure by industry as an input to production of goods and services, as well as their transportation – as used in traditional economics (input/output matrices) – that is key to the calculation of direct, indirect and induced effects of infrastructure investment;
- The indirect consumption of public infrastructure by industry and governments in the movement of their employees;
- The indirect consumption of public infrastructure by industry and governments in the health and skills development of their employees (current and future).

A broader productivity coupling of public infrastructure with production activities exists when infrastructure is a constraint on production.[30] That is, when public infrastructure is regionally insufficient, current and future production that can occur in that region is constrained. It is the indirect consumption of public infrastructure by industry, households and governments that is a key component of the 'systems effects' alluded to.

Additional systems effects occur as asset values may change with public infrastructure investment, which can have consequent impacts upon investment, debt and private migration choices. For example, the value of homes near a new transit stop increase in many cases. This value proposition is particularly evident in the presence of existing public infrastructure deficits and a growing population.

Such systems effects require the identification and accounting of both financial (e.g., realized input and output, investment/debt decisions) and non-financial events (e.g., expected demand, expected supply, policy and planning choices, activity location choices). Additionally, the fact that households, industries and governments have to compete with each other under their own unique budget constraints (e.g., income, expenses, assets, ability to borrow) adds an additional layer of complexity which must all be reconciled in order to construct and simulate an internally-conserved, consistent, and cohesive system.

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[30] This conforms to the roots of stock-flow consistent economic models: see Macedo e Silva, A., Dos Santos, C. H., 2008. *The Keynesian Roots of Stock-flow Consistent Macroeconomic Models*. Levy Institute of Economics of Bard College, Working Paper no. 537.

In order to simultaneously account for many of the economic and productive impacts generated as a result of regional public infrastructure investment and the unique constraints on the economic players as they compete, agent-based modeling is employed. The ability to measure and understand such outcomes and manage the computational complexity required is at the heart of CANCEA's systems-based platform, *Prosperity at Risk* (PaR).

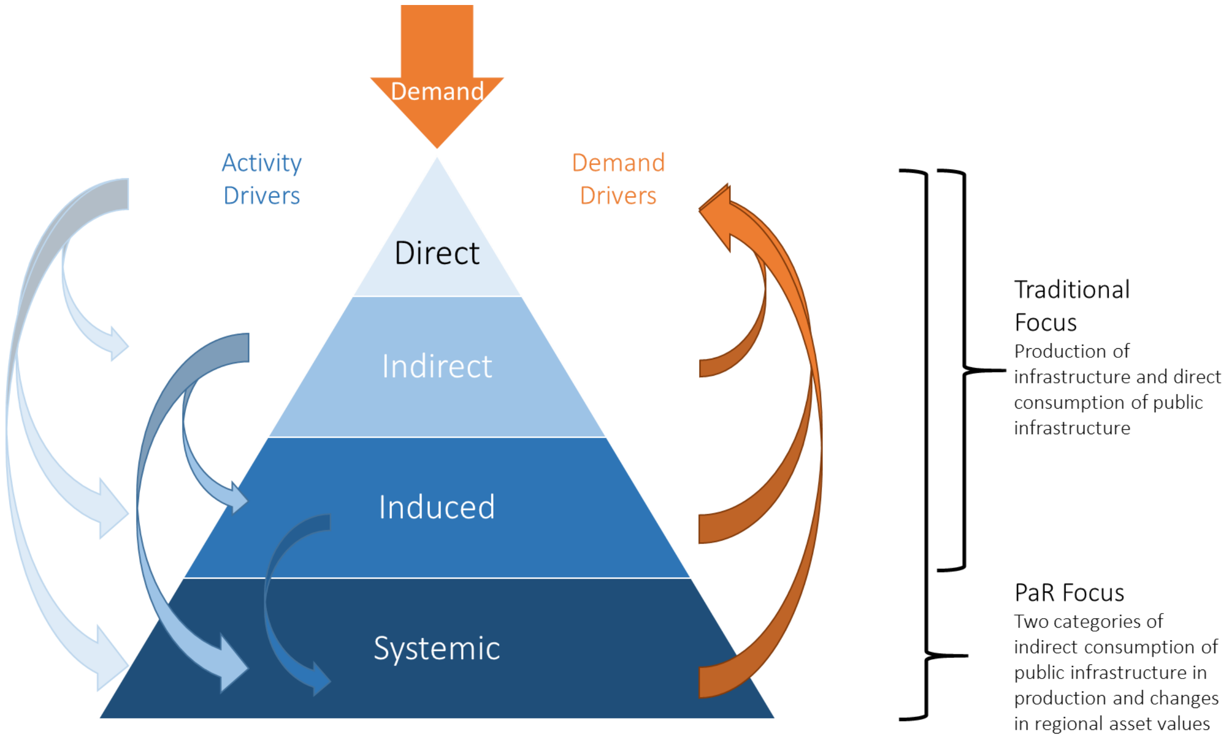
In a sentence: PaR is a more realistic and powerful agent-based simulation platform for geo-spatial socioeconomic analysis that is consistent with the principles of 'new economic geography'.[31] In slightly plainer language, it is a complex "big data" computer system that simulates the interactions of more than 40 million virtual agents (individuals, households, corporations, governments, and non-profit organizations) that are encoded with behavioural rules that enable them to make decisions, act based on those rules, and be influenced by the actions of others. Each agent can have over 850 features and interacts with other agents across 235 industries and 440 commodities within 5,000+ census areas across Canada. Per step in time, this equates to over 19 billion interaction measurements, including the buying and selling of goods or an individual paying taxes. But it does so by scrubbing, linking, and testing masses of data and focusing precisely on the key drivers of behaviour. Further, agents' behavioural features, such as their confidence in achieving outcomes or their tolerance towards risk (under normal and near-ruin circumstances) may change or evolve due to local circumstances or external stimuli, allowing unanticipated behaviors to emerge. These are only identified by way of experimental simulation.

Central to PaR's framework is agent-based modeling in the context of systems theory, the notion that all elements of an economy and society are connected to relevant others and influence one another both directly and indirectly. This occurs through a series of linkages between entities in the system, giving rise to impacts stemming from some catalytic investment, for example, that are not immediately obvious. Using PaR's interconnected modules (i.e., regional groups of processes/activities), the systemic impacts of an investment can be accurately ascertained through the linked analysis of health, social, and economic outcomes. The agent-based PaR framework has been cross-model validated through comparison with the baseline macro-economic outputs of third party demographic and economic models (to the extent that those models capture what PaR is measuring), as well as through back-testing of historical data.

Unlike traditional input/output models, PaR, is able to capture the systemic dependencies of infrastructure and industry by coupling infrastructure to private capital investment and productivity. In doing so, PaR is able to account for productivity constraints that will be encountered if infrastructure investment is not made, such as insufficient transportation investment leading to goods movement constraints. (It is also important to note that, unlike the traditional approach, agent-based modeling is able to identify the long-term productivity increase generated in the economy as a result of the investment.)

[31] See Tsekeris and Vogiatzoglou. 2010. *Multi-Regional Agent-Based Economic Model of Household and Firm Location and Transport Decisions.* European Regional Science Association conference papers.

Figure 12 Systemic dependencies in infrastructure evaluation



A.2. Simplified Walk-through of PaR Approach

To aid in the conceptual understand of PaR's approach to infrastructure evaluation modelling, this section provides a simplified walk-through of the various processes at work to show how an investment in public infrastructure propagates through the system. A staged approach of process representation is used for convenience only and does not reflect actual PaR processing. PaR processes as events occur, simultaneously where relevant.

Process 1: Demand for public infrastructure:

- Various orders of government have an expected demand for infrastructure from industry and households.

Process 2: Government decision to supply public infrastructure: the relevant government makes the decision to supply expected infrastructure demand which results in:

- Government tendering for the production of the infrastructure with a successful bidder;
- Governments and industries revise their output targets, investment and debt needs.

Process 3: Project financing:

- Government (or P3 consortia) competes in credit markets and borrows money when needed to fund infrastructure project.

Process 4: Direct and indirect competition for factors of production:

- Construction (direct) and intermediate industries (indirect, i.e., suppliers) under their own expectations compete in markets for factors of production (e.g., goods, services, labour, capital).
- Ongoing, industry (along with households and governments) compete in credit/investment markets for credit, equity capital, and investment sales.
- Ongoing, households regionally seek employment and payment of wages.

Process 5: Regional production of public infrastructure by industry: Direct and indirect industries fulfil in-part or full their required factors of production and produce target output (or a fraction of target output if limited by insufficient factors of production):

- Government (or P3 consortia) pays for work in progress;
- Industries receive revenue, pay for intermediate goods and services, pay taxes and receive subsidies (respective governments);
- Households produce labour regionally (labour retention, new hires, released), receive wages, and pay taxes to respective governments;
- Other government transfers are received or paid (dependent on income and household characteristics);
- Investment incomes and debt expenses are paid.

Process 6: Induced impacts of production of infrastructure by industry:

- Household income is spent on consumption of goods and services or saved via investments;
- Industry expected consumer demand responds to additional income (under budget constraints and spending vs saving preferences);
- Target industry outputs respond to changes of consumer expected demand resulting in additional direct demand for goods and services (with responses described in the previous step) under budget constraints.

Process 7: Systems impacts of use of public infrastructure by agents:

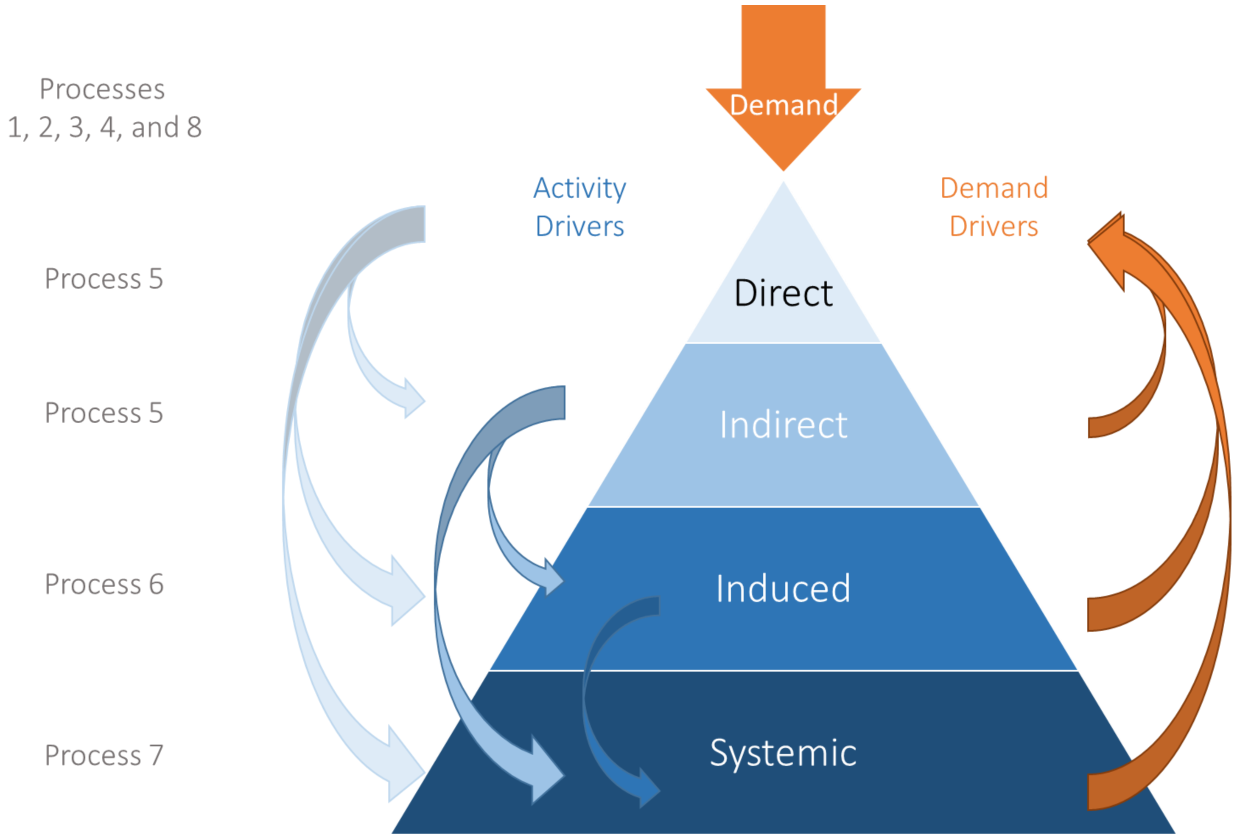
- Supply of public infrastructure impact on government, industry, and households:
    - is a direct and indirect factor of production to industry, government and households (described above);
    - changes the regional utility/valuation of capital assets.
- Government responds to change in supply of factor of production. Government operation/maintenance of infrastructure changes expectations and government production going forward.
- Industry responds to change in supply of factor of production in different locations (e.g., expectations, productivity, profit margins change, firm location).

    - Now able to meet unmet demand where infrastructure was a limiting factor of production.
    - Sees increased profit/wage share of output value.
    - May relocate where profit/wage share can be increased (with restrictions on labour and availability of other factors of production).
- Households respond through demands on public infrastructure use in different locations (relocation, municipal housing investment intentions, location change of consumption).
- Increased incomes result in increased consumer demand and capital investment expectations leading to increasing target industry output and direct demand (return to step 5).

Process 8: Other ongoing demographic considerations that can influence the above processes:

- Endogenous demographic and labour force changes: change in number of people (age, sex, skills) through births, deaths, inter-regional migration (already mentioned), international emigration, or retirements.
- Exogenous policy changes: federal government may or may not be adding to the population through international immigration throughout the simulated time period.
- Change in number of people changes household numbers and structure.
- Change in supply of labour, consumers, consumer demand expectations, government services requirements, utilization of public infrastructure (factor of production for industry & households), demand for infrastructure.

Figure 13 Systemic dependencies in infrastructure evaluation as processes in PaR



A.3. Systemic Dependencies Drive Results Away from Traditional Analysis

With the inclusion of the system dependencies discussed, the results of the analysis tend to diverge away from what is usually reported in the literature. That is, for those with economic analysis inclinations, there is likely to be an inherent 'sticker shock' reaction to the agent-based results presented in this report. Traditional economic input/output analysis will typically associate a $1 billion investment in public infrastructure with job creation of around 9,000 to 17,000 job-years and GDP growth of around $0.8B to $1.6B (Haider, Crowley and DiFrancesco 2013). Results that emerge from agent-based modeling of the same phenomena is likely to raise the interest of proponents of traditional input/output analysis.

As discussed, system effects are defined by a complex range of interdependencies between agents and the economy in which they interact. In doing so, agent-based results capture not only the stimulus impact that would result from an investment, but the range of indirect consumption impacts (productivity coupling) and asset revaluations (and consequent choices) that occur. That is to say, relevant public infrastructure investment changes the status quo. As such, we do not assume that the economy will continue to look like the current status quo into the future if a necessary investment is not made, like many cost/benefit analyses do.

The results of traditional input/output analysis usually pick up the stimulus effects of infrastructure spending and these results are almost always positive. In contrast, systems effects can be either positive, neutral or negative which allows analysis to determine if the spending is either an investment or a cost. It is this feature of the system impacts that make it a key measure of economic risk, as when:

- Systems impacts are positive: The infrastructure created provides an economic function that is:
  - a measure of benefit if done appropriately (implementation of form) which can be viewed as an investment by the system
  - a measure of what economic activity is at risk if not done
- Systems impacts are zero: The infrastructure created provides no economic benefits beyond the usual stimulus impacts
- Systems impacts are negative: The infrastructure created appears to be functionally inappropriate and a cost from an economic perspective. Justification would require non-economic arguments.

The nature of positive systems effects must be recognized as not an independent measure of the value of public infrastructure, but as a contribution by the many factors that combine to create value (a point often misunderstood). That is, to yield such an impact, it is necessary for additional events to occur in order for the infrastructure investment to be productive (which then become a measure of the risk to the productivity of infrastructure investments). This includes growth in private residential and non-residential private capital investment, additional public infrastructure investment at federal and municipal levels of government, wage growth, increased consumer and government consumption, and growth in taxation revenues.

The nature of interdependencies inherent to agent-based modeling imply that while this portfolio of events occur in tandem, they are each necessary in order for the other results to manifest as they do in the set. It is also important to note that these effects are not linear, and therefore cannot be assumed to occur as the sum of their parts (e.g., changes in asset values, new employment opportunities) or within the same year of the public infrastructure investment.

Systems modeling is akin to solving a multidimensional problem (much like a Rubik's cube). Inherently, these problems cannot be solved one dimension at a time, being at their very essence non-linear. Instead, a combination of relationships must be recognized in order to allow for the identification of value creation, as well as the underlying interdependencies and risks. Thus it becomes clear that there are a number of additional impacts that combine with job creation and GDP growth to generate value as a result of each $1 billion invested in infrastructure. Identification of these events (additional impacts) then becomes a measure of the risks to the productivity of public infrastructure investment; if they were not to occur, investment in public infrastructure would become unsustainable. Hence the need for such activities as economic development, planning and stakeholder co-ordination to mitigate such risks.

APPENDIX B. GLOSSARY

Agent	An autonomous individual, firm or organization that responds to cues from other agents and their environment using a set of evidence-based behavioural rules in response to those cues.
Agent-based modeling (ABM)	A framework for modeling a dynamic system, such as an economy, by means of individual agents, their mutual interaction with each other, and their mutual interaction with their environment(s).
Business case	An evidence-based argument in favour of a given choice.
Consortium	A group of private sector players with varying expertise that join together – often through a Special Purpose Vehicle (i.e., a new and temporary corporation) – to bid on and execute (if they win) an infrastructure project.
“Curse of the megaproject”	The notion that large and complex infrastructure projects are very often over-budget or delayed due to numerous biases and behaviours.
Demand risk	The risk that an infrastructure asset is constructed in order to meet a public demand that fails to show up, lowering the economic return of the asset.
Employment	The number of employed residents living in a region, in a given year. These residents may work within their region of residence or may commute outside of the region to work.
Financial close	The point at which financing obligations are determined and agreed to by both the procuring authority and the delivering consortia.
Headline risk	The risk that a news story reduces the value of an organization (e.g., stock prices, voter favourability).
Infrastructure financing	The provision of money when needed for the construction (and maintenance) of infrastructure assets. Separate from infrastructure funding.
Infrastructure funding	The ultimate source of money used to pay for the construction (and maintenance) of infrastructure assets.
Jobs	The number of jobs located in a given region, in a given year. These may be held by residents of the respective region, or may be held by individuals commuting in from other regions.
Job-years	Equivalent to person-years of employment, refers to the amount of work typically performed by one person working full-time for one year.
Lifecycle	The period that starts with an assets creation and ends with its demolition.
Optimism bias	The percent difference between an expected value and the actual result, and comes from not fully incorporating all the risks involved.
Output specifications	Performance specifications (over the contract period) agreed to by the consortia.
Private capital investment	The investment of the private sector into capital assets (e.g., factories).

Productivity coupling	Unlike most traditional economic models, *Prosperity at Risk* is able to measure the productivity impact of infrastructure investment on other factors of production, such as capital and labour. This feature is referred to as productivity coupling.
***Prosperity at Risk* (PaR)**	An event-driven, agent-based, microsimulation platform that tracks over 50 million agents for all of Canada by the end of a simulation. It simulates the economy's processes, including consumption, production, labour force dynamics, as well as evolving financial statements of agents. It conserves the flows of people, money and goods.
Public private partnership (P3)	Joint, cooperative arrangements between a private sector consortium and a public sector authority for at least two of the services required to: design, build, finance, operate, and maintain the infrastructure assets needed to deliver a public service. Cooperation is structured with long-term, integrated contracts that serve to transfer risks (at a cost) from the public to the private sector when the private sector is better placed to manage those risks.
Public sector comparator (PSC)	A hypothetical, risk-adjusted costing of a project delivered by the public sector to deliver to given output specifications.
Retained risk	Risks that remain exclusively in the domain of the public sector authority when best able to manage them.
Risk Premium	The premium charged by bidders to compensate for the additional risk transferred to them under P3.
Shadow bid (adjusted)	A hypothetical, risk-adjusted costing of a projected delivered by the private sector (via P3) to deliver to given output specifications. 'Adjusted' shadow bids adjust for risks retained by the public sector and add anciliary costs (e.g., legal, architectural, project management, and other fees).
Stipulated price contract	A contract specifying a fixed price typically used to construct a pre-designed asset (i.e., one that does not use output specifications).
Substantial completion	The point at which an asset is ready for use as intended.
System effects	Impacts that transcend direct, indirect and induced effects, which are not traditionally measured by economics. These impacts arise from the relationship between every economic agent and the environment in which they operate, as they influence one another's states and behaviours.
Systems approach	The belief that in complex systems, the whole is not equal to the sum of its parts. Such an approach requires the understanding that different combinations of assets can have different values for agents and that agents have different constraints and desires, and cannot be treated as aggregates.
Traditional procurement	Procurement of a project using a stipulated price contract for construction of an asset.
Value for Money (VfM)	The difference between the public sector comparator and the adjusted shadow bid. If positive, there is a risk-adjusted value to undertake the project as a P3.

APPENDIX C. LIST OF PROJECTS ANALYZED BY ASSET CLASS AND LOCATION

Health

Alberta

Devonshire Care Centre

British Columbia

Abbotsford Regional Hospital & Cancer Centre
BC Cancer Agency Centre for the North
BC Children's and BC Women's Redevelopment Project
Fort St. John Hospital & Residential Care Project
Gordon & Leslie Diamond Health Care Centre
Interior Heart and Surgical Centre Project
Jim Pattison Outpatient Care and Surgery Centre
Kelowna and Vernon Hospitals Project
North Island Hospitals Project
Penticton Regional Hospital Patient Care Tower
Royal Jubilee Hospital Patient Care Centre
SHOAL Centre
Surrey Memorial Hospital Redevelopment and Expansion: Emergency Department and Critical Care Tower
VIHA Residential Care & Assisted Living Capacity Initiative

Ontario

Bluewater Health Sarnia
Brampton Civic Hospital
Bridgepoint Hospital
Cambridge Memorial Hospital Capital Redevelopment
Casey House Facility Replacement Project
Centre for Addiction and Mental Health (CAMH) Phase 1B
Credit Valley Hospital Phase II Redevelopment
Credit Valley Hospital Priority Areas Redevelopment Phase III
Erinoak Kids Centre for Treatment and Development
Etobicoke General Hospital Redevelopment, Phase 1 Patient Tower Project
Hamilton General Hospital
Hawkesbury and District General Hospital Redevelopment
Hôpital Montfort
Humber River Regional Hospital
Joseph Brant Memorial Hospital Redevelopment
Juravinski Hospital and Cancer Centre
Kingston General Hospital
Lakeridge Health
London Health Sciences Centre (M2P2)
London Health Sciences Centre (M2P3)

- Markham Stouffville Hospital
- Milton District Hospital Redevelopment
- Niagara Health System
- North Bay Regional Health Centre
- Oakville-Trafalgar Memorial Hospital
- Ottawa Paramedic Service Headquarters
- Ottawa Regional Cancer Centre (Ottawa Hospital)
- Ottawa Regional Cancer Centre (Queensway Carleton Hospital)
- Peel Memorial Centre for Integrated Health and Wellness
- Providence Care Hospital
- Public Health Laboratory at MaRS Center Phase 2
- Quinte Health Care Belleville Site
- Ron Joyce Children's Health Centre
- Rouge Valley Health System
- Royal Ottawa Mental Health Centre
- Royal Victoria Regional Health Centre
- Runnymede Healthcare Centre
- Sault Area Hospital
- St. Joseph's Health Care London (M2P1)
- St. Joseph's Health Care London (M2P2)
- St. Joseph's Health Care London (M2P3)
- St. Joseph's Healthcare Hamilton - West 5th Campus
- St. Joseph's Regional Mental Health Care (London and St. Thomas)
- St. Michael's Hospital Redevelopment Project
- St. Thomas Elgin General Hospital
- Sudbury Regional Hospital
- Sunnybrook Health Sciences Centre
- Toronto Rehabilitation Institute
- Trillium Health Centre (M-Site Redevelopment)
- Trillium Health Centre (Q-Site Redevelopment)
- University of Ottawa Heart Institute: Cardiac Life Support Services Redevelopment Project
- Waypoint Centre for Mental Health Care
- Windsor Regional Hospital
- Women's College Hospital
- Woodstock General Hospital

Other

- Centracare Psychiatric Care Facility
- Central Nova Scotia Correctional Facility & East Coast Forensic Hospital
- Restigouche Hospital Centre
- Saskatchewan Hospital North Battleford - Integrated Correctional Facility
- Stanton Territorial Hospital Renewal Project
- Swift Current Long Term Care Centre Project

Quebec

CHU Sainte-Justine

Haut-Richelieu-Rouville (Montérégie) Long-Term Care Centre (CHSLD)

Laval Long-Term Care Centre (CHSLD)

McGill University Health Centre (MUHC) Glen Campus

Montreal University Hospital Center (CHUM)

Montreal University Hospital Research Centre (CRCHUM)

Saint-Lambert Long-Term Care Facility (CHSLD)

Transportation

Alberta

Anthony Henday Drive Northeast

Anthony Henday Drive Northwest

Anthony Henday Drive Southeast

Edmonton Valley Line LRT Expansion Project (Phase 1)

Stoney Trail Northeast

Stoney Trail Southeast

British Columbia

Canada Line

Evergreen Line Rapid Transit Project

Golden Ears Bridge

Kicking Horse Canyon (Trans-Canada Highway) - Phase 2

Sea-to-Sky Highway Improvement Project

Sierra Yoyo Desan Resource Road

South Fraser Perimeter Road

William R. Bennett Bridge

Multiple

Confederation Bridge

Ontario

Billy Bishop Toronto City Airport Pedestrian Tunnel Project

City of Barrie P3 Transit Service Project

Eglinton Crosstown LRT

GO Transit East Rail Maintenance Facility

Highway 407 East Phase 1

Highway 407 East Phase 2

Highway 407 ETR

ION Stage 1 LRT Project (Waterloo LRT)

Ontario Highway Service Centres

Ottawa Light Rail Transit - Confederation Line and Highway 417 Widening Project

The Rt. Hon. Herb Gray Parkway

Union Pearson Express

York Viva (BRT) Bus Rapid Transit Project

Other

- Charleswood Bridge
- Chief Peguis Trail Extension
- Disraeli Bridges
- Fredericton-Moncton Highway
- Highway 104
- Iqaluit International Airport Improvement Project
- Regina Bypass
- Route 1 Gateway Project
- Saskatoon Civic Operations Center Phase One
- Saskatoon North Commuter Parkway and Traffic Bridge Replacement
- Trans-Canada Highway (New Brunswick)

Quebec

- Autoroute 25
- Autoroute 30
- Lachine Train Maintenance Centre AMT
- New Bridge for the St. Lawrence (Champlain replacement)
- Pointe-Saint-Charles Commuter Train Maintenance Centre
- Québec Service Areas

Utilities

Alberta

- Evan-Thomas Water and Wastewater Treatment Facility
- Fort McMurray West Transmission Project
- La Biche Biological Nutrient Removal (BNR) Wastewater Treatment Facility
- Okotoks Water & Wastewater System

British Columbia

- Britannia Mine Water Treatment Plant
- John Hart Generating Station Replacement
- Kokish River Hydroelectric Project
- Port Hardy Water & Wastewater Treatment System
- Sooke Wastewater System
- Surrey Biofuel Processing Facility Project
- Vancouver Landfill Gas Cogeneration Project

Ontario

- Britannia Landfill Gas to Electricity Project
- Bruce Nuclear Power Plant
- Sudbury Biosolids Management Facilities
- Waterloo Landfill Gas Power Project

Other

- Moncton Water Treatment Facility
- Regina Wastewater Treatment Plant
- Saint John Safe Clean Drinking Water Project (SCDWP)

Justice

Alberta

Calgary Courts Centre

British Columbia

Five Corners Project

Okanagan Correctional Centre

RCMP E Division Headquarters

Surrey Pretrial Services Centre Expansion Project

Ontario

Cook Chill Food Production Centre

Durham Consolidated Courthouse

Elgin County Courthouse

Forensic Services and Coroner's Complex

OPP Modernization Project

Quinte Consolidated Courthouse

Roy McMurtry Youth Centre

South West Detention Centre

Thunder Bay Consolidated Courthouse

Toronto South Detention Centre

Waterloo Region Consolidated Courthouse

Other

Moncton Law Courts

Quebec

Sorel-Tracy Detention Centre

Other

Alberta

Alberta Schools (ASAP I)

Alberta Schools (ASAP II)

Alberta Schools (ASAP III)

Calgary Composting Facility

British Columbia

Emily Carr University of Art + Design Redevelopment

Prospera Place

Site C Clean Energy Project Worker Accommodation

Vancouver Single Room Occupancy (SRO) Renewal Initiative

Ontario

Archives of Ontario - Offsite Archival Storage

Bell Sensplex

Budweiser Gardens

CSEC Long-Term Accommodation Project

Enterprise Data Centre Borden Expansion

Humber College Institute of Technology and Advanced Learning

Mohawk 4-Ice Centre

Ontario Ministry of Government Services Data Centre
Pan Am Athletes' Village
Pan Am Games Venues - Markham Pan Am Centre, Etobicoke Olympium & Pan Am Field Hockey Centre
Pan Am Stadia and Velodrome
Pan American Aquatics Centre, Field House and Canadian Sport Institute Ontario
Powerade Centre
Richcraft Sensplex
Shenkman Arts Centre & Orleans Town Centre
Sheridan College Hazel McCallion Campus (Phase 2)

Other

Connecting Small Schools
Government of Nunavut Buildings
Leo Hayes High School
Mackenzie Valley Fibre Link Project
Moncton / Rexton Schools
Moncton Downtown Centre
Mosaic Stadium
Nova Scotia Schools
Red Ball Internet Centre
Saskatchewan Joint-Use Schools Project #1
Saskatchewan Joint-Use Schools Project #2

Quebec

Montréal Concert Hall

Source: Canadian Council for Public-Private Partnerships

APPENDIX D. RESULTS TABLES

Table 4 Impact on GDP ($) per dollar invested (aligns to Figure 4)

	Alberta	British Columbia	Ontario	Quebec	Rest of Canada
Health	$3.0	$3.1	$2.4	$2.2	$1.4
Justice	$2.7	$2.5	$1.8	$2.2	$1.1
Transportation	$4.2	$3.3	$3.2	$3.8	$1.5
Utilities	$3.1	$2.2	$2.2	-	$1.8
Other	$2.3	$2.0	$2.0	$2.7	$1.2

Table 5 Contributions of direct, indirect, induced and systemic impacts to GDP (aligns to Figure 5)

	Health	Justice	Other	Transport-ation	Utilities
Direct	45%	53%	53%	35%	45%
Indirect	15%	19%	15%	12%	14%
Induced	23%	26%	27%	19%	23%
Systemic	17%	3%	5%	34%	18%

Table 6 Impact on private capital investment ($) per dollar invested (aligns to Figure 6)

	Alberta	British Columbia	Ontario	Quebec	Rest of Canada
Health	$0.7	$1.0	$0.9	$1.0	$0.5
Justice	$1.3	$0.9	$0.8	$0.8	$0.6
Transportation	$1.6	$0.9	$1.0	$1.1	$0.9
Utilities	$1.3	$0.6	$1.0	-	$0.8
Other	$1.3	$0.7	$0.7	$0.6	$0.7

Table 7 Impact on total wages ($) per dollar invested (aligns to Figure 7)

	Alberta	British Columbia	Ontario	Quebec	Rest of Canada
Health	$1.2	$1.3	$1.1	$1.0	$0.7
Justice	$1.1	$0.9	$0.6	$0.9	$0.5
Transportation	$1.9	$1.6	$1.5	$1.5	$0.6
Utilities	$1.3	$1.0	$0.9	-	$0.8
Other	$1.2	$0.9	$0.9	$1.3	$0.5

Table 8 Impact on total tax revenue ($) per dollar invested (aligns to Figure 8)

	Alberta	British Columbia	Ontario	Quebec	Rest of Canada
Health	$0.8	$0.7	$0.9	$0.9	$0.5
Justice	$0.7	$0.7	$0.7	$0.8	$0.4
Transportation	$1.1	$0.9	$1.0	$1.1	$0.4
Utilities	$0.9	$0.7	$0.7		$0.5
Other	$0.6	$0.6	$0.7	$0.7	$0.4