

The Economic Value of Surety Bonding in British Columbia

A networked agent-based economic assessment

August 2017



**CANADIAN CENTRE FOR
ECONOMIC ANALYSIS**

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CANCEA is grateful to those executives and experts who shared their expertise and insights via interviews that were conducted as part of the research process for this project. The profile of those organizations interviewed included several of the largest general contractors and subcontractors operating in Canada.

EXECUTIVE SUMMARY

Surety bonds protect against non-performance and non-payment risks associated with the operation and financial standing of construction enterprises and their relationships. In a highly integrated economy, understanding the economic value of surety bonds is no simple task and requires:

- The ability to model the contractual and commercial **connections** (network structure) that permeate through industries – particularly in the construction sector – to understand the “domino” impacts of financial and operational distress on the broader economy;
- A **significant amount of data** on the interaction of the surety industry with stakeholders in the construction sector and the broader economy, how stakeholders purchase surety products, construction projects on which surety bonds are used, and the performance of projects with and without surety bonds; and
- Analytical tools designed to quantify the economic impacts that extend beyond aggregate economic activity and include impact on jobs and taxes, and quantify where risks and rewards (intended or otherwise) arise for **different stakeholders**.

British Columbia’s construction industry plays a significant role in the province’s economy, currently contributing approximately 9% of provincial GDP and employment. Nationally, insolvency rates in the construction industry are at a 35 year low, averaging around 3.4 insolvencies per 1,000 firms over the last 10 years. This is almost 6 times lower than in the early 1990s when insolvency rates were averaging 17.7 per 1,000 firms.

The objective of this research project was to conduct a network-based quantitative analysis of the economic value of surety (e.g., performance bonds, payment bonds) for different construction activity (with varying capital types), and industries (i.e., public and private capital projects). The aim is to illuminate surety’s value proposition for policy-makers, the general public, and other key stakeholders.

A **performance bond** is a special class of contract signed by a contractor (the ‘principal’) and a surety in which the contractor and surety guarantee to a third party (an ‘obligee’, often a project owner) that the contractor will perform a specific construction contract. If the contractor fails to perform, then the project owner may look to the surety under the bond for the costs of completing the contract and additional related costs.

Labour and material payment bonds (or simply, **payment bonds**), a related class of bonds, are signed by a contractor and its surety and guarantee that the contractor will pay its subcontractors, suppliers and labourers on a specific contract. If the contractor fails to honour its payment obligations then subcontractors, suppliers and labourers may look to the surety for payment under the bond.

Findings at a glance

A majority of public construction work in British Columbia is carried out under bonded contracts. Using surety industry datasets of over 150,000 surety records and Prosperity at Risk® network modeling of the British Columbia economy, we found that:

Reduced risk of insolvency	<p>Non-bonded construction firms are ten-times more likely than bonded companies to suffer insolvency at any given point in time. As a result, firms whose projects are bonded see a general reduction in project delays through a combination of reduced insolvencies and delays associated with insolvencies.</p> <p>The process of underwriting bonds on construction projects appears to contribute to capital and operational adequacy in bonded businesses.</p>
Protection of economic activity (GDP)	<p>In the current low interest rate economy, insolvencies in the construction industry are at a 35 year low. At these current insolvency rates, surety bonds protect 1.4 times more economic activity in British Columbia than their premium cost (over \$1.4M of GDP protected per \$1M premiums paid), which amounts to the equivalent of around 9 full time jobs (or about \$0.7M in wages) protected per \$1M of premiums paid.</p>
Economic risk management benefits	<p>In the 1990s, insolvencies had reached 6 times current levels. At these insolvency rates, surety bonds could protect 9 times more economic activity in British Columbia than their premium cost (about \$9M of GDP per \$1M in premiums paid), which amounts to the equivalent of 63 full-time jobs (or about \$4M in wages) protected per \$1M of premiums paid.</p>
Fiscally responsible	<p>In the current economic environment, governments could recover \$0.4M per \$1M of premiums paid on public infrastructure projects. In a higher insolvency environment, such as the early 1990s, this could increase to \$2.7M per \$1M of premiums paid indicating that governments (in total) become a net beneficiary of surety bonding.</p>
Extent of industry coverage is important	<p>The size and significance of the surety bond benefits vary depending upon the level of risk in the economy (e.g., increasing interest rates, debt levels, recession, and global shocks). The highest economic and fiscal benefits versus the premium costs required comes from a policy that requires a combination of performance and payment bonds – with 100% of public infrastructure projects bonded.</p>

British Columbia's construction industry and surety bonds

A majority of public sector construction work in Canada is carried out under bonded contracts. Based on the surety bond data, it is estimated that companies involved in non-bonded projects have an insolvency rate ten times greater than companies with bonded projects. While insolvency tends to occur more frequently in smaller companies, the insolvency of larger companies appears to be much more disruptive to the economy. Further, an examination of the surety bond data shows significant project delivery overruns associated with companies in financial stress (negative net worth, operating losses).

As highlighted in previous work by CANCEA (2016)¹, there are significant economic consequences to project delays, as infrastructure delivery is about “right size, right place, and *right time*”. If something stands in the way of delivering or enabling a vital public service at that time, then the economy suffers. As a result, any delays could have a much greater impact than simply the direct financial cost of the delay, and there is potentially significant economic value to preventing construction delays.

Many additional impacts of surety bonding may not be directly observable in the public records of insolvencies or project delays. This includes changes to a firm's financial planning or intervention of the surety companies. In particular, these additional impacts could include:

- **Capital and operational adequacy:** The process of underwriting bonds on construction projects involves pre-qualification of bidders by surety companies, which is observed to accompany an improvement in the capitalization and financial management within the construction industry. This benefit reduces the potential and the severity of construction insolvencies;
- **Project completion and subcontractor payment:** Costs of restructuring, financing and completing failed projects can be significant and can be transferred to a surety under a bond. For example, during the five-year period ending in 2016, the surety industry paid out more than \$200 million under bonds in Ontario to fund completion of projects and pay subcontractors, suppliers and labourers²; and
- **Prevention of financial distress:** While insolvencies are distinct legal and financial events, operational and financial distress (such as cash flow issues, inability to access needed credit or materials) often occurs prior to the recording of an insolvency. Given their role as guarantors to a process, surety providers will at times support firms through a project or program of work when needed, thereby reducing the incidence of solvency and enabling contractors to complete projects and pay subcontractors, suppliers and labourers.

¹ An analysis of 200 P3 infrastructure projects in Canada found that delays in construction could have significant long-term economic impact particularly as the size of the portfolio of delayed projects increases

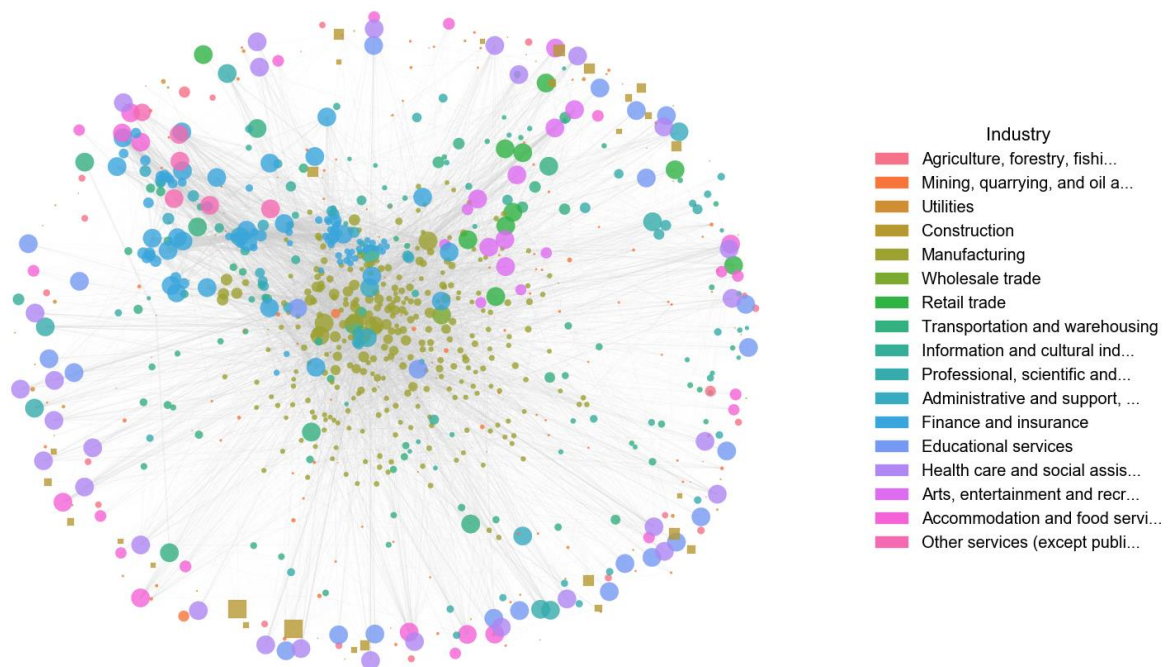
² Source: MSA Research Inc.

Industry network structure

The construction sector is part of a complex economic system, with a vast array of networked interactions between many diverse “agents”. How things are connected within such a system impacts how actions reverberate through it. Without a good understanding of the key linkages between economic agents (e.g., firms), the measurement of the risks that could occur when an adverse event hits is significantly limited. Metaphorically, a car accident on the highway may only do severe damage to the few cars directly involved, but many more cars get affected due to traffic delays.

In order to capture the full effect of interruptions in the network, it must be modelled for over 3 million companies in 20 industry sectors across Canada and British Columbia. The figure below shows the connections between the largest 1000 companies in British Columbia. A typical construction company, could have a dozen linkages (e.g., suppliers, subcontractors or customers), each of which may have a dozen of its own, and so on. If such a company were to become insolvent, its suppliers would have an increased chance of insolvency depending upon how dependent it is on the insolvent company. In addition, if a supplier or subcontractor became insolvent, it could introduce delays in other projects of its customers. Surety bonds can help protect against such interruptions in the network.

Largest 1000 Companies by # of Employees - British Columbia



The types of bonds considered in this analysis are performance bonds (which protect ‘upstream’ so the project is completed) and payment bonds (which protect ‘downstream’ so that suppliers and

subcontractors are more likely to remain solvent). Section 2.2 presents more details on the industry network structure.

Given the complexity of modeling the range of networked interactions and impacts required for this research – a networked agent-based model was required. CANCEA's *Prosperity at Risk*® (PaR) computer simulation platform is used by several Ontario Ministries and municipalities to perform socio-economic impact analysis, and was used for this project. This had allowed for the detailed simulation of dependencies between:

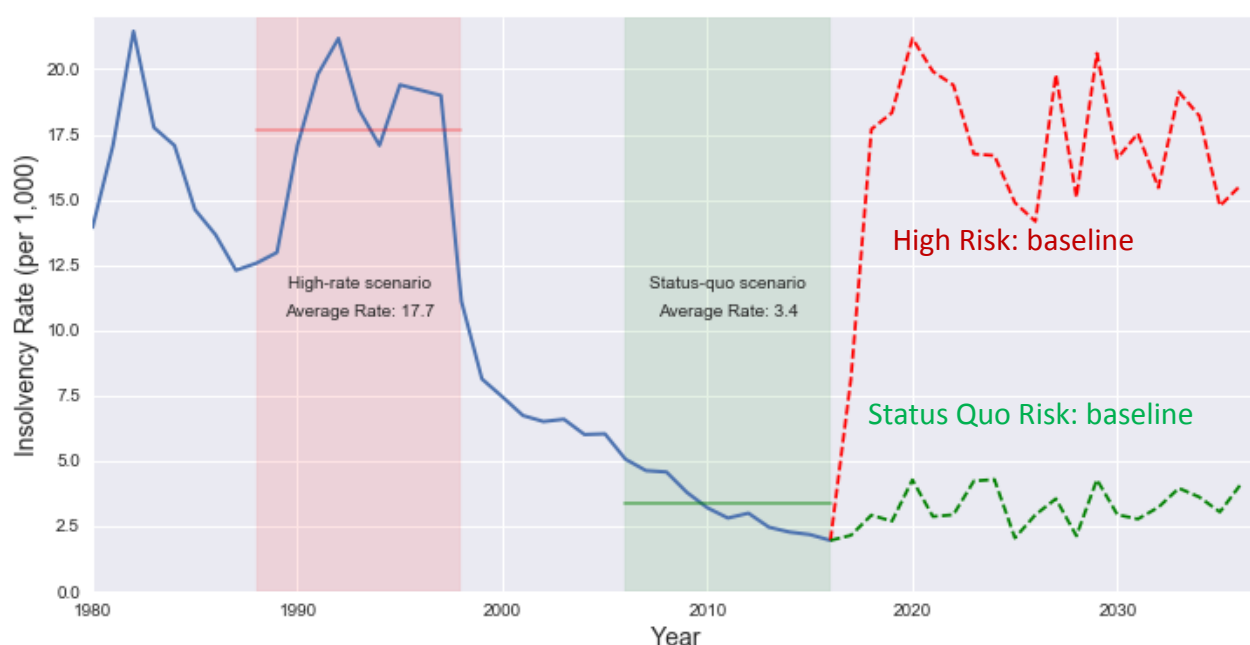
- 178,000 British Columbia firms across 17 industries, 3 levels of government, 30 commodity types, 25 capital types;
- More than 150,000 surety records (see Appendix A for details);
- Other PaR (*Prosperity at Risk*®) datasets (e.g., many down to detailed geographic areas) on demographics, income statements and balance sheets, consumption patterns, labour force statistics, and commuting choices, among many others; and
- Public data on insolvency from the Office of the Superintendent of Bankruptcy Canada (OSBC) provide a good sense of the rates of insolvency by province and industry. These data allowed for a detailed comparison between the experience of bonded firms and those in the construction sector overall.

One benefit of using PaR is that multiple scenarios can be run and compared against a baseline. This shows, across thousands of randomized trials, the likely outcomes (plus the not-so-likely ones), and their broad impacts across the entire economy. It also allows for in-depth sensitivity analysis (employed here) to help decision-makers determine “optimal” policies. To investigate this topic in detail, we define eight broad scenarios (two risk scenarios times four bonding scenarios), and investigate over the next 20 years (2018-2037).

Results

Surety bonds can significantly reduce the insolvency rates within the construction sector. In the following figure the two risk scenarios are shown:

- The **blue line** shows the historical national number of **construction firm insolvencies** since 1980;
- The dashed **green line** shows a typical modelled rate of insolvency in the **status-quo risk baseline** with no surety bonds; and
- The dashed **red line** shows a typical modelled rate of insolvency in the **high-rate risk baseline** with no surety bonds.



Companies that exhibit financial distress (negative net worth and operating losses) or become insolvent can lead to project delays:

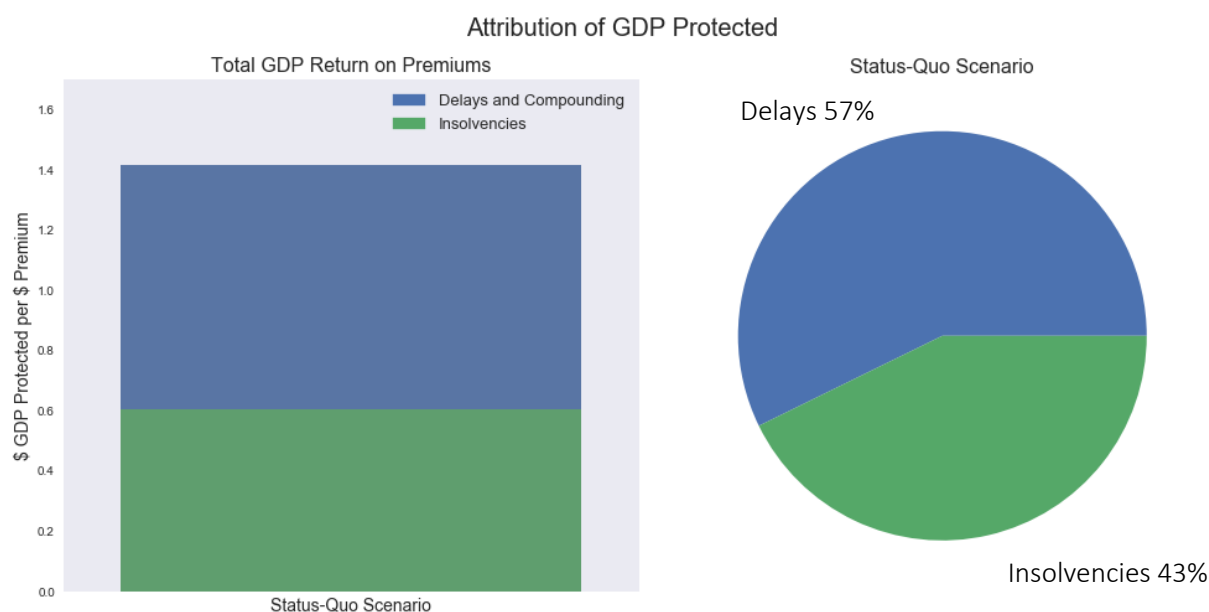
- Directly if company is the general contractor; or
- Indirectly if a supplier becomes insolvent (possibly through the previous insolvency of a different customer).

By introducing the performance and payment bonds, we see a significant reduction in delays for bonded projects through reduced insolvencies. As a result, many more projects are completed closer to the scheduled time with a large decrease in projects with significant overruns, particularly in the high risk case.

Status Quo Scenario

With performance and payment bonds, insolvency rates are reduced considerably resulting in significant economic benefits. The figure below shows that in the status quo scenario, if 100% of public infrastructure projects have performance and payment bonds, over \$1.4 of GDP is protected per dollar of surety bond premium. Of this benefit, 43% is attributed to the reduction in insolvencies of companies, while the remaining 57% are systemic benefits which arise from having the infrastructure built on time.

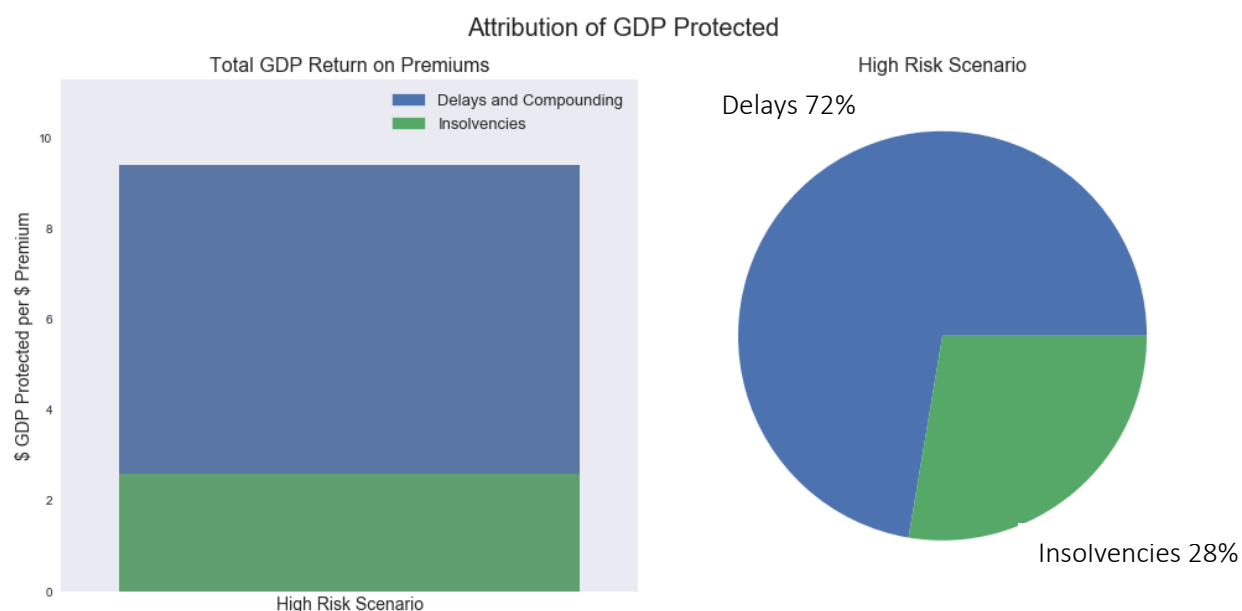
Attribution of GDP protected to insolvencies (green) and delays and compounding effects (blue) in the status-quo scenario



High Risk Scenario

In the high risk scenario, as illustrated in the figure below, if 100% of public infrastructure projects have performance and payment bonds, over \$9 of GDP is protected per dollar of surety bond premium. Of this benefit, 28% is attributed to the reduction in insolvencies of companies, while 72% are systemic benefits which arise from having the infrastructure built on time, given a larger aggregate portfolio of projects delayed at higher insolvency rates. Similar differences exist for the other outcome metrics such as tax revenue and jobs.

Attribution of GDP protected to insolvencies (green) and delays and compounding effects (blue) in the high-risk scenario



The following table highlights some of the key economic metrics from the analysis. A greater proportion of the benefits in the status quo risk case are driven by direct insolvencies, while the high-risk case benefits result more from the network effects.

Summary economic impacts of surety (public infrastructure)

Risk level	Economic activity, per \$1 of premium	% of benefits arising directly from reduced insolvencies	Associated tax revenue, per \$1 of premium
Status Quo	\$1.4	43%	\$0.4
High Risk	\$9	28%	\$2.7

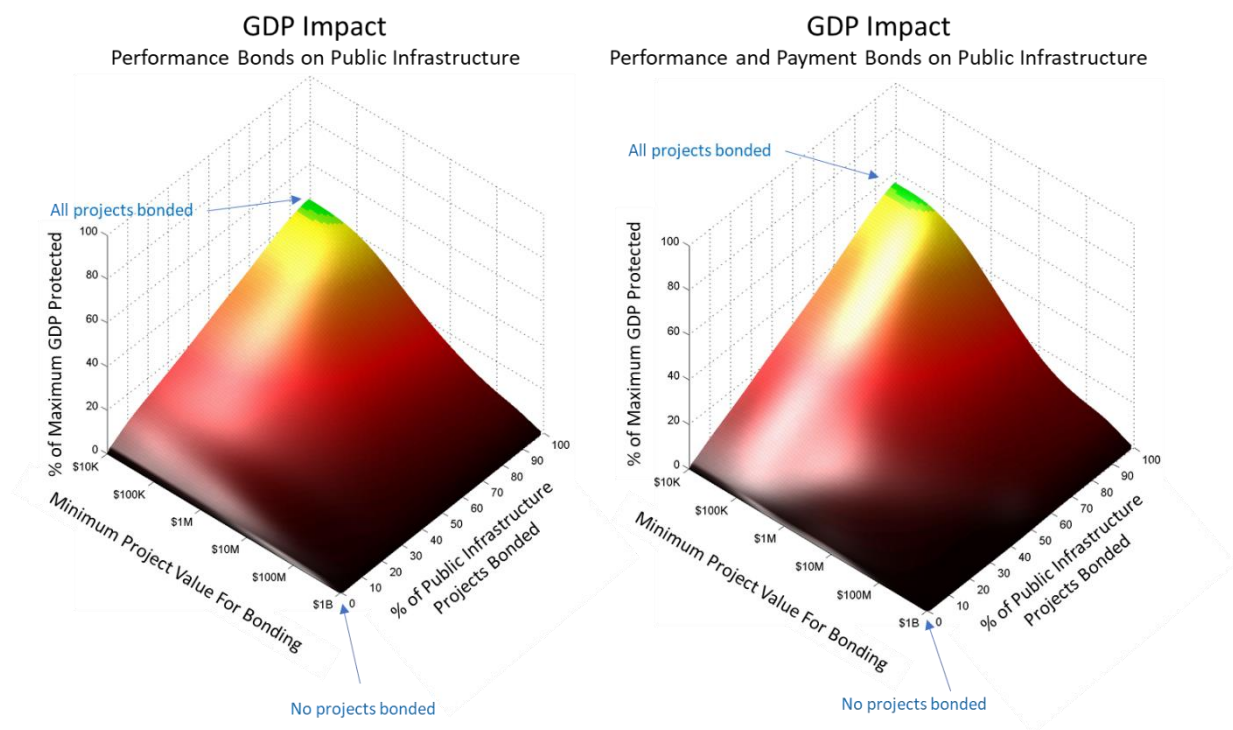
These results reflect status quo and high risk scenarios in which 100% of projects are bonded with both performance and payment bonds, and reflect the best economic outcomes. When only a portion of projects are bonded, or when performance bonds are used without payment bonds, the economic outcomes are less than optimal.

Surface plots of economic activity were generated for every combination of:

- Minimum project size for bonding (x-axis); and
- Percentage of public infrastructure projects bonded (y-axis).

The illustrations below show the expected GDP results of each combination (z-axis using percent of maximum GDP seen in the analysis). As can be seen, the most optimal outcome for the economy as a whole occurs when 100% of public infrastructure projects are bonded.

Bonding of Public Projects: Sensitivity of economic impacts, percentage of high risk scenario maximum



The “% of maximum GDP Impact” is the percent of the maximum GDP results we saw in any scenario. When payment bonds are used together with performance bonds the GDP outcomes increase. In addition, the combination of performance bonds with payment bonds shows significant economic outcomes at the 100% project coverage level without negative marginal returns.

Conclusion

Credit and operational risk in the construction industry can vary significantly due to the movement of interest rates, recession, supply shocks, debt levels, credit squeezes, and so on. Currently, Canada enjoys historically low rates of construction insolvencies, which has been aided in part by the fact that many public infrastructure projects are surety bonded.

By understanding, quantifying and simulating the way in which the construction industry is connected between suppliers and subcontractors of materials and services and to the broader economy, the value of providing surety guarantees for projects to the socio-economic network of British Columbia could be measured. We found that the impact of surety – and the additional due diligence its use ensures – is generally positive, regardless of scenario run (assuming some coverage). But a combination of performance and payment bonds – with a focus on infrastructure investments – yields the highest benefits (measured in terms of GDP growth) relative to the costs required.

Further, the process of underwriting bonds on construction projects appears to contribute to capital and operational adequacy in bonded businesses and reduces financial stress and insolvencies.

The benefits in the high insolvency rate scenario (e.g., 1990s levels) were particularly significant and about 7 times greater than in the status quo scenario despite the insolvency rates being only 5 times higher, which is a demonstration of how important network analysis is to such impact analysis. The analysis of the high risk scenario indicated that the benefits include:

- \$9 of economic activity protected per \$1 of premium paid;
- \$2.7 of tax revenue (across all levels of government) protected per \$1 of premium paid by all levels of government³; and
- 63 job-years protected per \$1M of premiums.

Future research

Further, we have assumed zero administrative cost to construction companies in undertaking the due diligence required by the surety. (This is somewhat similar to capital adequacy requirements in the banking sector, where there are imposed costs to being a bank to ensure that the entire system isn't "infected" by poor performance.) Such research might suggest that there is a *minimum* project threshold that should be imposed, to avoid an undue burden on smaller construction companies.

³ This analysis did not investigate any asymmetry in the government sector with respect to the level of governments which may pay the premium and those that receive the benefits. However, see CANCEA's report, "Ontario Infrastructure Investment: Federal and Provincial Risks and Rewards (Canadian Centre for Economic Analysis, 2016).

1. INTRODUCTION

Understanding the true economic value of surety is no simple task. It requires the ability to model the full network structure of industry – particularly in the construction sector – to understand the broad impacts of an adverse event. It also requires a significant amount of data on surety, such as who purchases it, what projects they work on, and what happens with those projects. Finally, it requires appreciating that economic impacts go beyond GDP; that they also include the likes of jobs and taxes, to understand where risks and rewards (intended or otherwise) may land. As such, as part of its industry advocacy work, the Surety Association of Canada (SAC) approached CANCEA to undertake network modeling, with major members confidentially providing significant amounts of data.

The objective of this independent report is therefore to provide the essential quantitative analysis of the economic value of surety (e.g., performance bonds, labour & material bonds) for different:

- Construction activity (with varying capital types); and
- Industries (i.e., public and private capital projects).

Using the framework established in previous and related work, CANCEA's unique modeling platform is utilized to demonstrate the value proposition for policy-makers, the general public, and other key stakeholders.

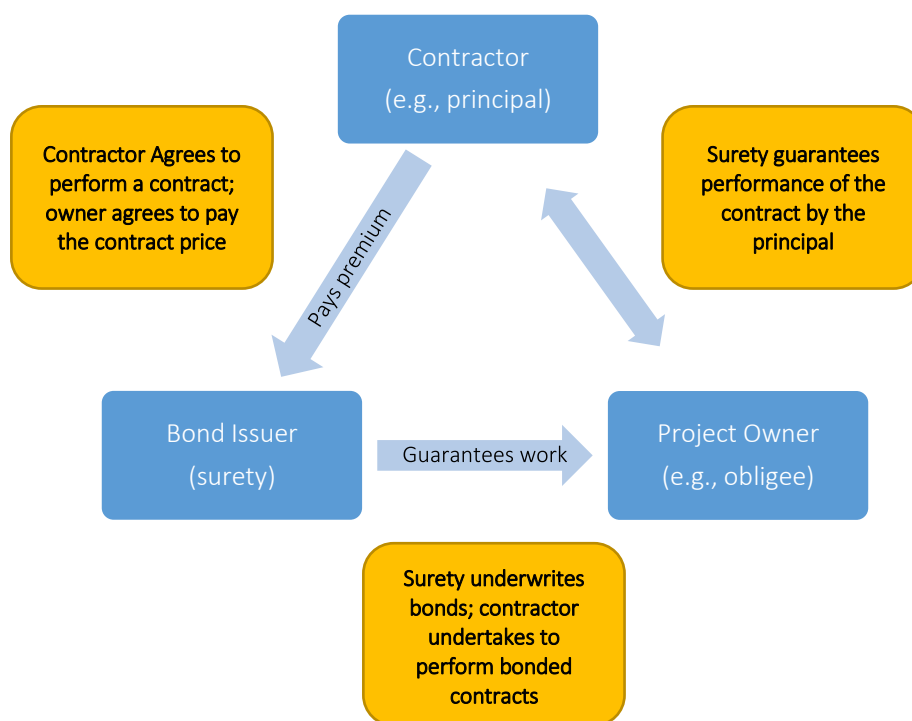
1.1 What is surety?

The enterprise of suretyship, where one person guarantees and answers for the performance of another person's obligations to a third party, is a form of performance security that has been effective and has persisted through time. Religious and civic laws have regulated the use of surety instruments in commerce and society since ancient times. By 1840, the first successful corporate Surety – Guaranty Society of London – was founded, and in 1935, the US federal *Miller Act* was established to require use of performance bonds for public works contracts in excess of \$100,000 and payment bonds for contracts in excess of \$25,000 (Surety Bonds Timeline, 2017). In 1992, The Surety Association of Canada (SAC) was formed by companies seeking advocacy independent of the insurance industry. SAC currently has close to 80 members.⁴

The diagram below illustrates the 3-party relationship that is at the heart of a surety bond. While the surety engages in a process of due diligence in evaluating the credit and performance capacity of a construction enterprise and often forms a business relationship with a contractor, the surety's primary obligation under a bond is to the obligee (often a project owner).

⁴ See <http://www.surety-canada.com/en/members/index.html/Surety/advanced-directory/search> for details

Figure 1 Basic surety diagram



Among the various types of surety bonds underwritten by the surety industry in Canada, this study focuses on performance bonds and payment bonds used in the construction industry. In the Canadian market, performance bonds typically have a value of 50% of the value of the bonded contract, and are normally issued in tandem with a payment bond also having a value of 50% of the bonded contract.

The proceeds of a payment bond are restricted and can be used only to pay qualifying subcontractors, suppliers and labourers on the bonded contract. Payment of these subcontractors and suppliers can preserve warranty on products, equipment and work, and can ensure continuity of a project team to avoid delay in completion of a defaulted project. A payment bond can also ensure payment of subcontractors and others who would otherwise seek recovery of unpaid accounts by registering a lien on the project or taking other legal action that could disrupt the completion of a project.

The proceeds of a performance bond are available to offset additional costs of completing a bonded contract in the event of the default of the principal contractor and financial protection is provided to a project owner against the risk of contractor default.

1.1.1 ASSURANCE RATHER THAN INSURANCE

While surety has commonalities with insurance and banking, it should not be confused with either. An insurance company typically gathers premiums from a large group of customers at risk of some adverse event occurring (e.g., a car accident). This creates a substantial pool of money that can be used to pay out the costs of adverse events to the small subset of customers to whom they occur, spreading the costs of such risk across all customers. Details gathered on potential customers are generally only used to

determine the premiums paid, without much regard for the individual characteristics that could determine actual “riskiness” (e.g., while people of a certain subgroup, like teenagers, may be more at risk in *general* of car accidents, *individuals* in that group may be excellent drivers).

But the fundamental idea of surety bonds is to *avoid* adverse events, because a surety company is putting up its own resources to ensure projects get completed. This makes surety bonds more like an extension of credit with the assumption that there will be no losses, such as co-signing a loan. This means that surety is more about *assurance* than *insurance*. A surety company assesses a contractor’s experience and track record (e.g., in financial and project management), capacity (both financial and performance), character, and other factors before deciding whether or not to issue a bond. If a particular contractor is deemed too risky, the surety will simply decline to issue bond. Premiums are collected to cover the costs of underwriting expenses, not to pay losses. Taking on an overly risky contractor can be a costly decision.

2. BRITISH COLUMBIA'S CONSTRUCTION INDUSTRY

British Columbia's construction industry⁵ plays a significant role in the province's economy, contributing approximately 9% of provincial GDP and employment. Over that period, the Canadian construction sector has built up a significant net worth, having grown their aggregate assets (net of liabilities) by nearly 500%.

Figure 2 Contribution of the construction industry to BC's economy (%)

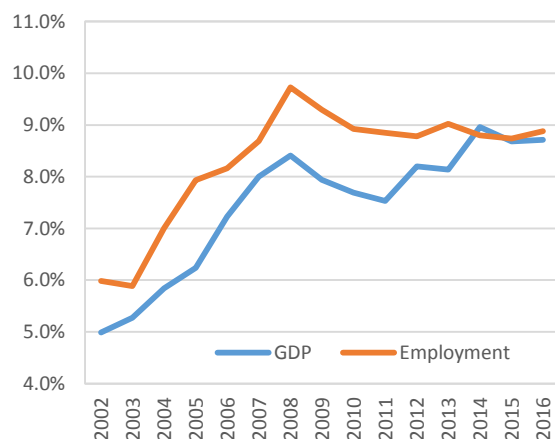
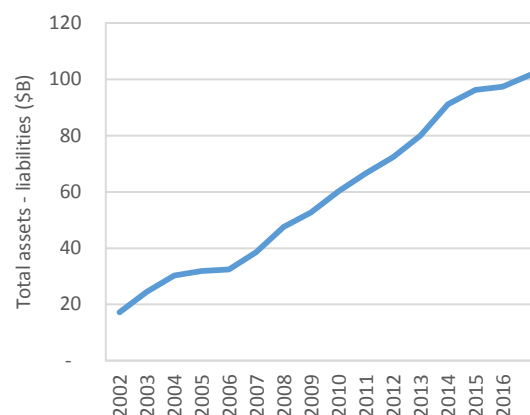


Figure 3 Net worth of the construction industry in Canada



Sources: Statistics Canada, tables 379-0028, 282-0008, and 187-0001

That said, this growth has come more from a return on capital investment than on operating profit margins.

Figure 4 Operating profit margin in Canada (%)

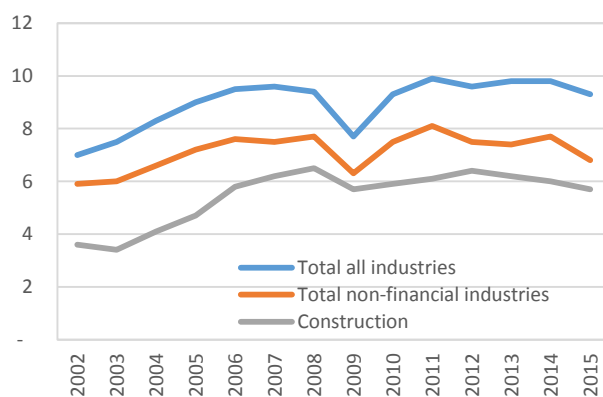
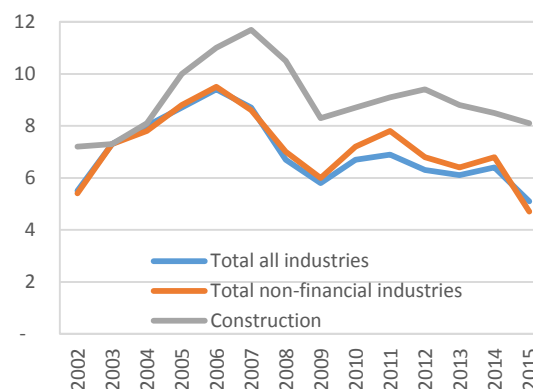


Figure 5 Return on capital employed in Canada (%)

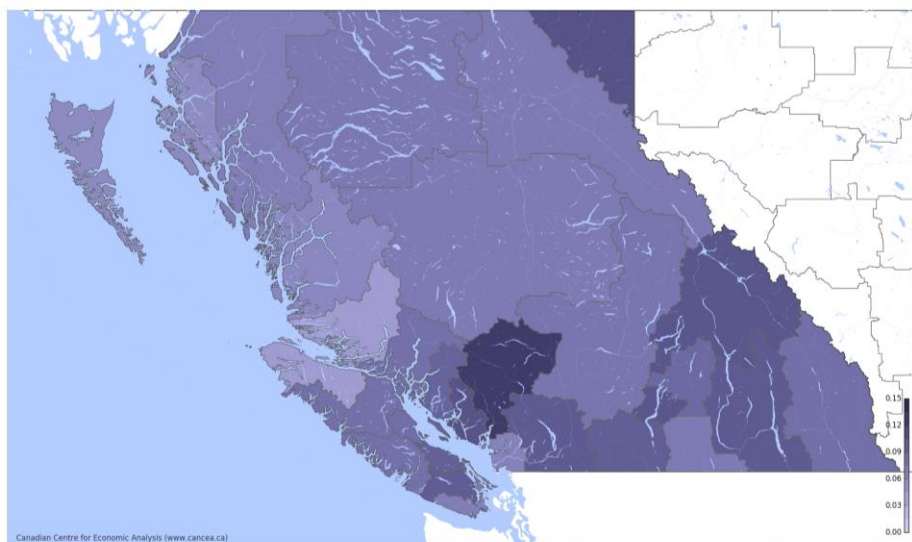


Sources: Statistics Canada, table 180-0003

⁵ For the purposes of this analysis construction includes building construction (non-residential – industrial, commercial, and institutional, plus residential); and engineering construction (e.g., transportation, water & wastewater, communications, and other engineering construction). Each has a public and private component.

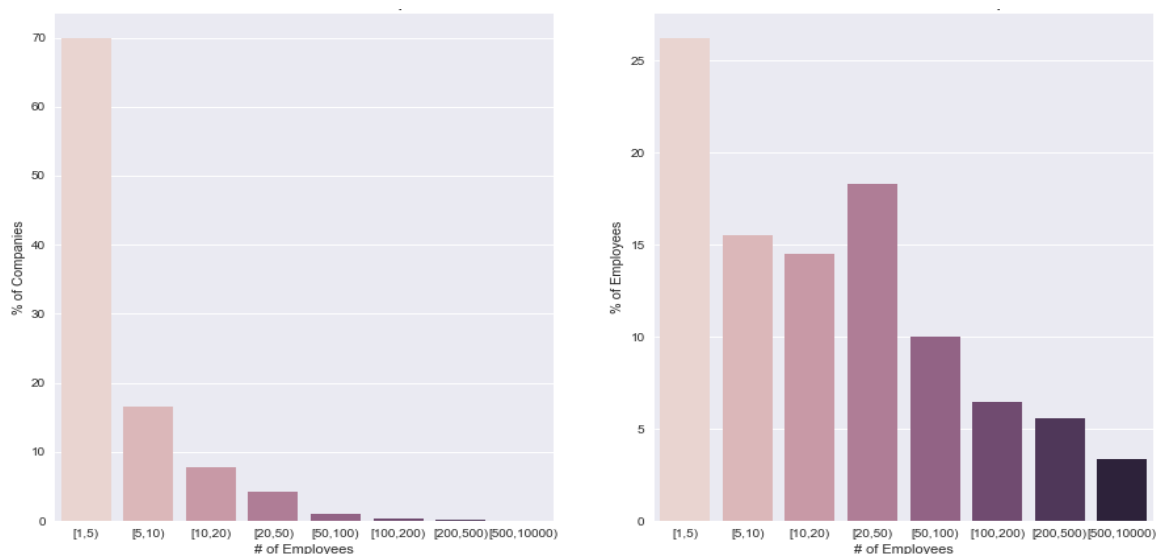
Further, construction employs a significant fraction of the population geographically distributed across the province.

Figure 6 Distribution of construction employees across British Columbia



This distribution stems from the fact that the construction sector is dominated by a large number of small companies, both in terms of the number of companies (over 2/3) and number of employees (over 1/4) and the construction is location dependent.

Figure 7 Canada's construction industry breakdown by size of firm

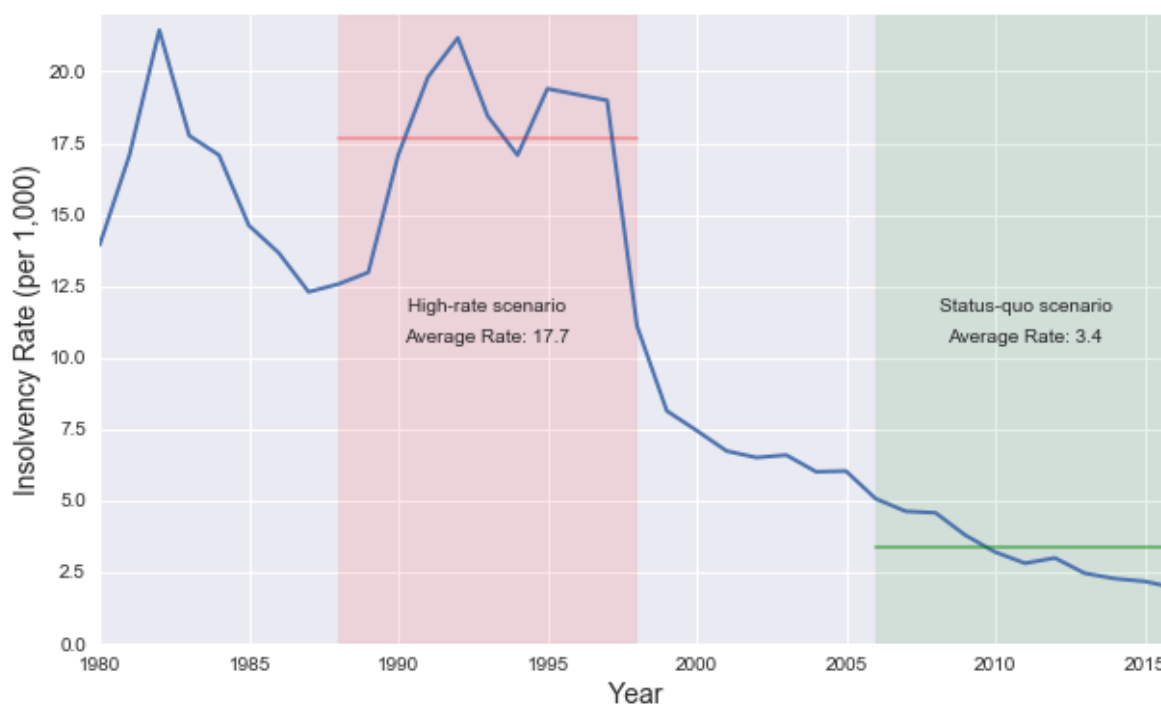


2.1 Risk in the construction industry

As discussed in previous CANCEA work, 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). 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).

Another driver is contractor insolvency. Currently, as shown in Figure 8 , the insolvency rate in the construction industry is at a 35 year low, having fallen consistently over the last twenty years.

Figure 8 Insolvency rates in the Canadian construction sector



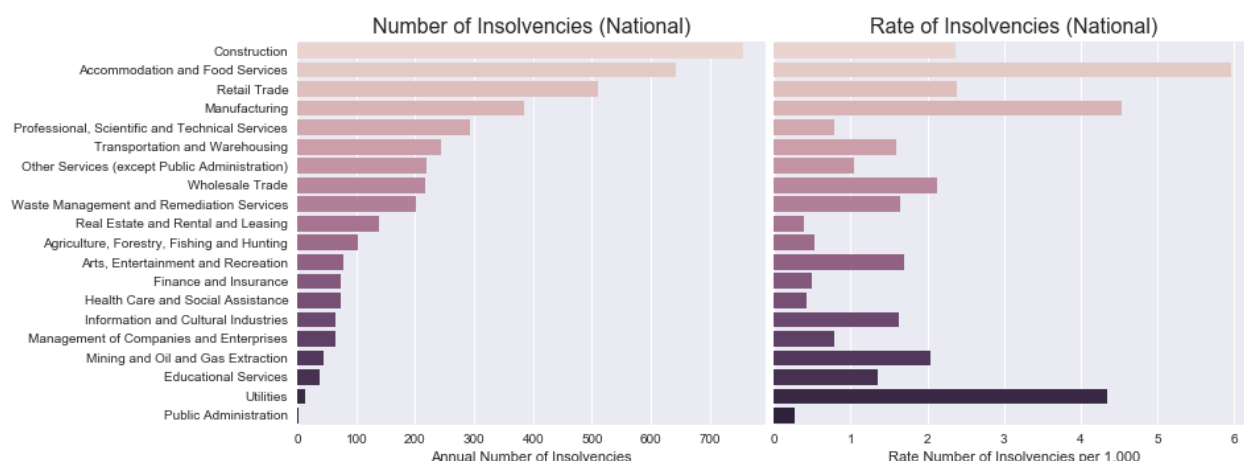
Part of that is likely due to the significantly low interest rate environment and the significantly increased amount of liquidity held by Canadian construction companies, who have seen the share of their (aggregate) assets held in cash nearly double from 7% in 2002 to 13% in 2016. However, underlying these trends are risks, for instance, in Ontario, the average collection period in construction has increased by nearly a quarter from 2002 to 2013, from 57.3 to 71.1 days (Reynolds & Vogel, 2016), and thus a larger “pot” of receivables has developed on corporate balance sheets (accounts receivable have grown as a share of total assets over that period by 36% to 19%). There are no readily available data to know whether these financial

trends are simply dominated by the larger players⁶ in the industry, though a review of the financial statements for a few of the bigger companies would suggest this to be the case.

Nonetheless, as shown in Figure 9 , over the last 5 years the construction sector in Canada has had:

- The highest absolute number of industry insolvencies;
- The 5th largest industry rate per 1,000 companies; and
- An insolvency rate significantly higher for smaller companies.

Figure 9 Number and rate of insolvencies by industry



The construction industry has been making efforts to reduce their exposure to risk. Part of this has come from the introduction of modern risk management practices that understand the role of the external environment (Baloi & Price, 2003; Fan, Lin, & Sheu, 2008), and that appreciate that different stages of a project face different risks and so should be managed differently (Nielsen, 2006).

2.2 Industry network structure

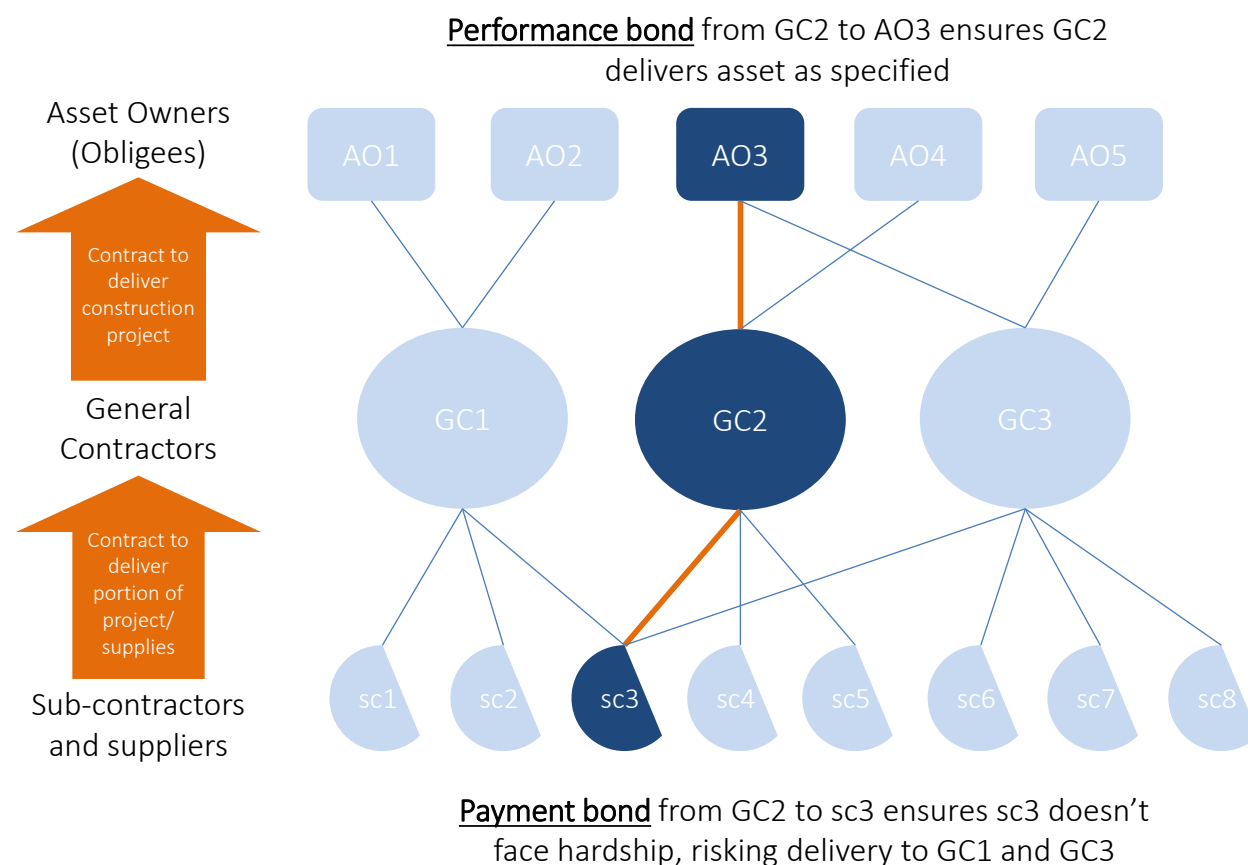
The construction sector is part of an incredibly complex economic system with a vast array of networked interactions between many diverse “agents”. If analysis only relies on averages to estimate causes and effects, then it only looks at the economy from the top down. But we are not averages. We behave differently. We offer different things to different people. And we all face different constraints.

In other words, how things are connected within a system impacts how actions reverberate through it. Without properly understanding the linkages between economic agents (e.g., firms), a full understanding of what happens when an adverse event hits is impossible. Metaphorically, a car accident on the highway may only do severe damage to the few cars directly involved, but many more cars get affected.

⁶ In the Canadian construction industry, the top 3 companies represent roughly 5% of the revenue generation and the next 10 companies another 5% (Sources: *On-site Magazine* and *Statistics Canada table 187-0001*)

As an example, Figure 10 illustrates the ease with which networked companies can indirectly impact other organizations within a network. Trying to model such a network top down would entirely lose these linkages, and hide knock-on effects from an interruption (e.g., from a financial hardship).

Figure 10 Simple representation of surety in a networked economy



Taking this to the fullest, in order to capture the effect of interruptions in the network, it must be modelled for over the 3 million companies in 20 industry sectors across Canada⁷. While difficult to represent graphically, Figure 11 presents a subsection of such a set of networked companies, by showing the linkages (inputs and outputs) between the largest 1,000 companies by industry (the size of marker here represents the number of employees). Figure 12 then shows an individual construction company (brown square), which has (say) a dozen linkages (e.g., suppliers or subcontractors), each of which has (say) a dozen of its own, and so on.

Therefore, if such a company were to become insolvent, suppliers would have an increased chance of insolvency, based on both their own underlying industry rates and a fraction of revenue from the insolvent customer. (Payment bonds remove the impact of fraction of revenue from insolvent customers but do not

⁷ For British Columbia, the full network includes 178,000 companies across: 17 industries and 3 levels of government, 30 commodity types, 25 capital types. Most companies have dozens of suppliers and customers

affect underlying industry rates.) On the flip side, if a supplier or subcontractor became insolvent, it could introduce delays in other projects depending on the fraction of inputs it supplies.

As such, surety bonds can help protect against interruptions in the network. The types of bonds considered here are performance bonds (which protect ‘upstream’) and payment bonds (which protect ‘downstream’).

Figure 11 **Network of 1,000 largest employers by industry**

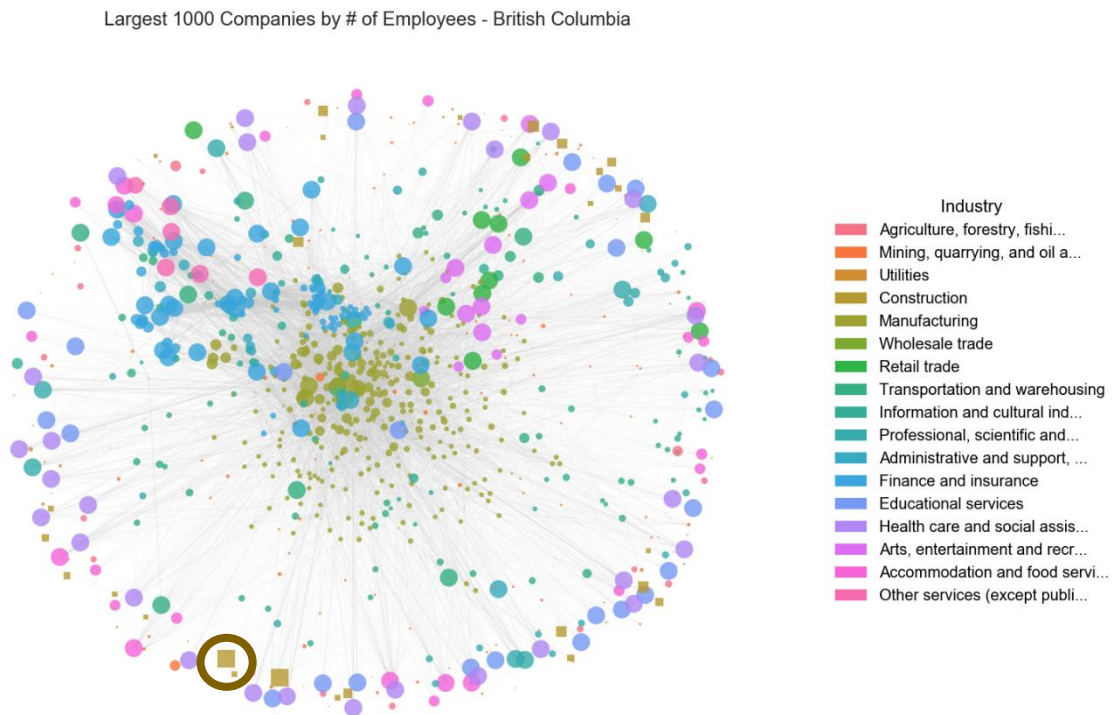


Figure 12 **Suppliers or subcontractors of one construction company (left) have their own connections (right)**



3. MODELING THE NETWORK

Given the complexity of modeling the range of networked interactions and impacts required for this project, a different approach is required. Improvements in computing power and data have given rise to a new method of socio-economic inquiry.

Agent-based modeling provides a framework for investigating dynamic, networked systems, such as an economy (with specific land-uses), by means of individual agents (e.g., households, businesses, governments), their mutual interaction with each other and their environment. *Prosperity at Risk*[®] (PaR) is CANCEA's "big data" computer simulation platform that incorporates social, health, economic, financial, and infrastructure factors in a networked system. This platform models agents as:

- **Individuals**, with individual budget constraints (e.g., income, expenses, assets, and liabilities) and production/consumption activities (dependent upon economic input/output tables), thereby recognizing the independence of their motivations and decisions; and as
- **Part of a spatial and economic network**, thereby recognizing the dependence of their economic decisions upon other agents (via, for example, policy, investment decisions, and land use).

As such, PaR simulates the interactions of more than 40 million agents (people, households, dwellings, companies, government) across Canada that are each encoded with financial, behavioural/motivational rules to guide their decisions, act based on those rules, and be influenced by the actions of others. This is enabled by an enormous "linked-path" database that links hundreds of disparate (and typically cross-sectional) data sources back to the very objects that created them (e.g., individual companies)⁸. This allows for the introduction of varied constraints and behaviours over time. The goal of such analysis is to identify the risks and rewards (intended or not) across various stakeholders.

Because PaR features the entirety of the Canadian economy and adopts a micro-simulation approach, all scenarios can be evaluated with precision regarding their impacts on various types of agents or sectors of the economy. This also allows for unforeseen spillover effects (or 'externalities') to be accounted for, tracked, and assigned to the correct cause, as agents dynamically adapt to their environments. Small changes in behaviour, spending, or infrastructure lead to local adaptations by agents, which then spread to others, such that all the relevant aspects of the economy reflect all the 'ripples in the pond'.

In this way, the breadth of effects can be tracked as they unfold geographically and temporally, and an intervention or scenario can be assessed holistically, such that all impacts are taken into consideration. The model is therefore realistically sensitive to the particular type of investment, intervention, or behavioural change with as few *a priori* assumptions as possible.

⁸ For example, PaR imbues in agents hundreds of data sources (e.g., Statistics Canada tables, many down to detailed geographic areas) on demographics, income statements and balance sheets, consumption patterns, labour force statistics, and commuting choices, among many others.

3.1 Methodology

In addition to the hundreds of data sources that have already been triangulated into agents in PaR, the larger members of the Surety Association of Canada (SAC) provided detailed (proprietary) claims data (collectively called the SAC data for simplicity) that included:

- Surety industry datasets of over 10,000 construction firms
- Over 150,000 bonded construction projects
- Over 3,000 surety claims

Additional details on the SAC data are provided in Appendix A.

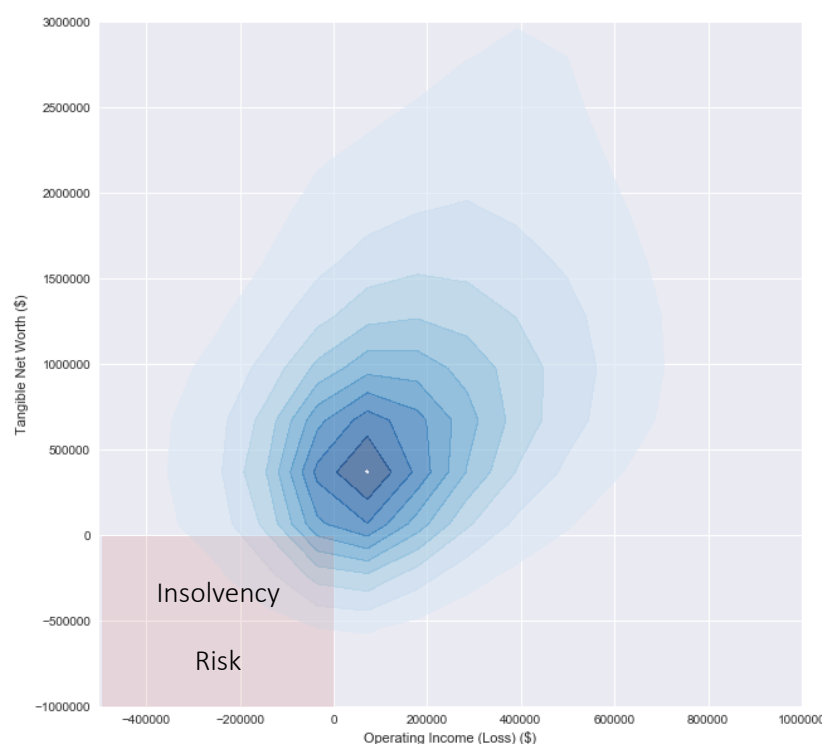
Further, public data on insolvency from the Office of the Superintendent of Bankruptcy Canada (OSBC) provide a good sense of the rates of insolvency by province and industry.

These data allowed for a detailed comparison between the experience of bonded firms and those in the general construction sector. Given that the number of companies involved with surety bonds is small relative to the number of construction-related companies overall, these average rates of insolvency provide a good estimate for the rate of insolvency for companies with non-bonded projects.

Given the number and distribution of firms in the construction industry, its dependence on other sectors, and the inherent (and often unforeseen) risks associated with construction, the industry writ large is affected by insolvency at a relatively high rate. Recall from Figure 9 that the industry has the highest absolute number of insolvencies across Canada on an annual basis, and has the 5th highest rate (per 1,000 companies), behind the likes of accommodation and food services, and retail trade.

However, identified by companies with large losses or expenses (greater than 50% of project value), and operating losses, and negative tangible net worth, Figure 13 shows that insolvencies are quite rare within the SAC data.

Figure 13 Distribution of companies by net worth and operating income (excluding extreme outliers)



This suggests that the due diligence that surety enforces, along with the surety itself (in cases requiring it), help to reduce strain in the economic network, although this does not apply to all companies evenly.

Individually, smaller companies are not eligible for larger projects since they do not have the resources available. As the project values requiring surety bonds decreased, a greater number of smaller companies would require their projects to be bonded. It is assumed for this project that any policy which may require surety bonds for small projects will not impose an undue burden on either the smaller companies or the surety. (This assumes no attrition of small companies due to the surety requirement.) As a result, they experience a reduction in insolvency (though stay at a higher rate than larger companies).

3.1.1 SCENARIOS

One benefit of using PaR is that multiple scenarios can be run and compared against a baseline. This shows, across thousands of randomized trials, the likely outcomes (plus the not-so-likely ones), and their broad impacts across the entire economy. It also allows for in-depth sensitivity analysis (employed here) to help decision-makers determine “optimal” policies. For this project, there are some key steps:

- *Define a ‘baseline’ capital investment profile:* construction (public and private) under the status quo
- *Assign companies to build projects:* Under the status quo, companies are randomly assigned to build the projects (accounting for insolvencies)
- *Quantify impacts of Surety bonds:* Vary the number of bonded projects to study the impact through changes in insolvency and project delays

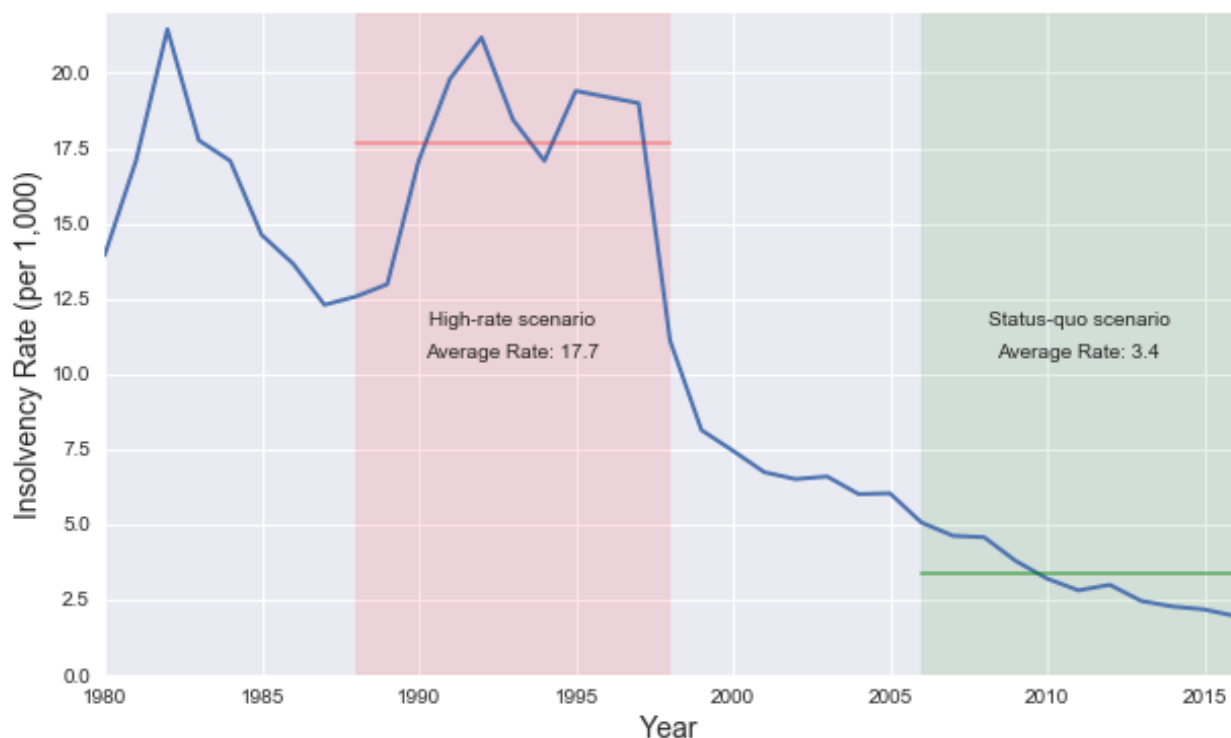
To investigate this topic in detail, we define four sets of projects and the related bonds issued. For varying project sizes, we consider – over the next 20 years (2018-2037) – the fraction of:

1. Public sector infrastructure (e.g., transportation and transit, health, education, water & wastewater) projects with only performance bonds;
2. Public sector infrastructure projects with only performance *and* payment bonds;
3. All construction (i.e., public plus residential/commercial/industrial construction and private engineering construction) projects with performance bonds; and
4. All construction projects with performance *and* payment bonds.

For each set, the analysis is performed:

1. Maintaining the current status quo insolvency rates – that is, maintain the average insolvency rate over the last 10 years (see Figure 14); and
2. Using ‘high-risk’ insolvency rates from the late-1980s to mid-1990s.

Figure 14 Insolvency rates in the Canadian construction sector



This leads to a total of eight broad scenarios, and a few key hypotheses:

- Insolvency rates for companies with non-bonded projects differ from those with bonded projects (could be tied to different capital levels as a correlating factor for insolvencies); and
- Projects that experience profit losses or have claims tend to have greater time overruns than those that don't after accounting for project size (difficult to attribute cause of overruns).

3.1.2 IMPACTS OF BONDS

To summarize some of the data used to help undertake the network modeling done in PaR, there is a noticeable variety in what happens to companies with bonded vs. non-bonded projects across Canada⁹.

First, as shown in Figure 15, the estimated difference in insolvency rates between bonded and non-bonded companies is almost a factor of ten. That is, non-bonded companies are ten-times more likely to go insolvent at any given point in time. Further, insolvency tends to hit smaller companies far more frequently than their larger counterparts (by orders of magnitude).

Figure 15 Comparison of insolvency rates in Canada's construction sector

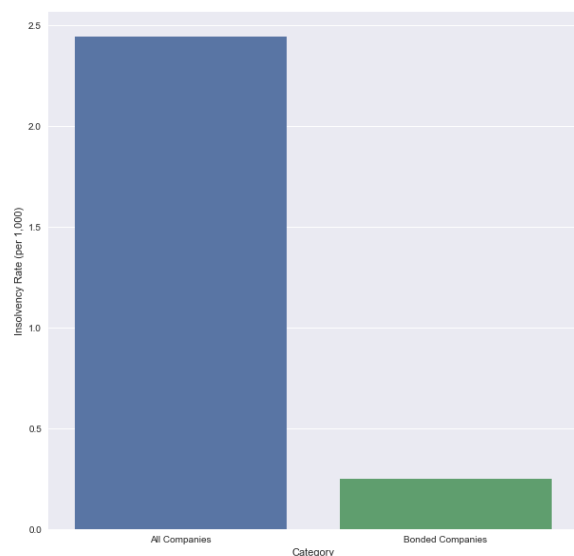
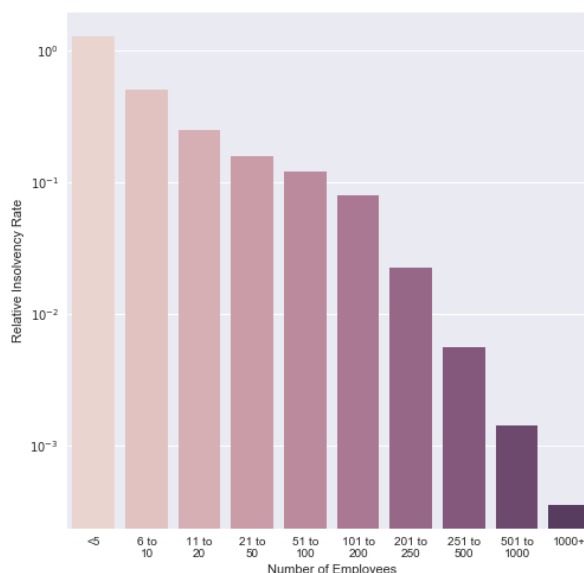


Figure 16 Relative insolvencies by firm size (by number of employees)



Further, as highlighted in previous work by CANCEA (2016)¹⁰, there are significant economic consequences to project delays, as infrastructure delivery is about “right size, right place, and *right time*”. If something

⁹ Limited data due to the relative infrequency of surety claims require that the impact of surety bond be evaluated on a national scale but the results can be applied regionally.

¹⁰ An analysis of 200 P3 infrastructure projects in Canada found that delays in construction could have significant long-term economic impact particularly as the size of the portfolio of delayed projects increases

stands in the way of delivering or enabling a vital public service at that time, then the economy suffers. Specifically:

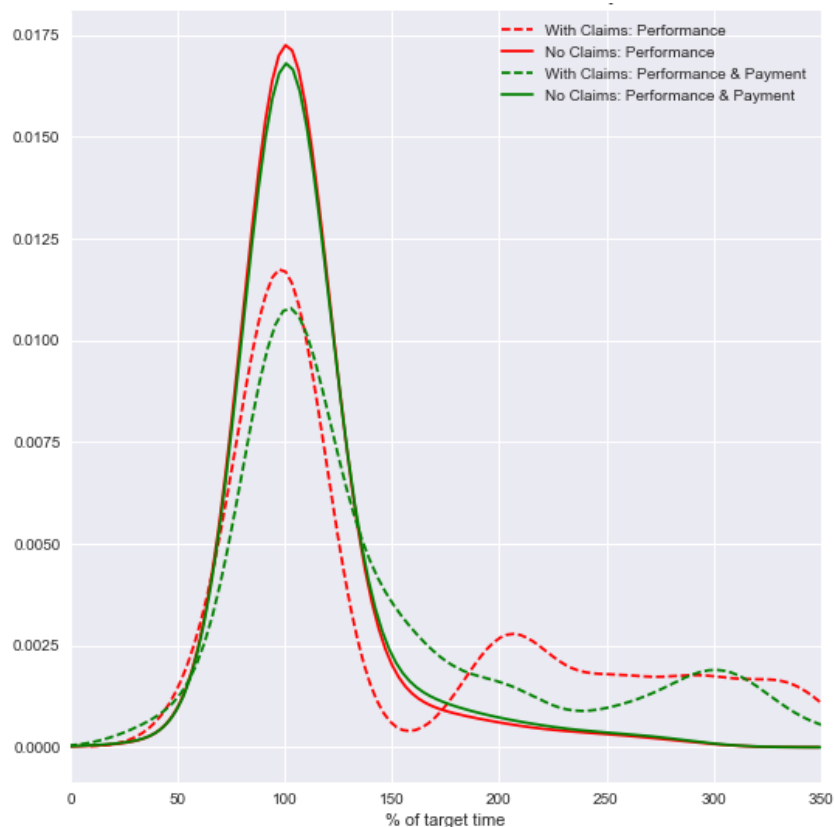
Since infrastructure plays a critical role in the efficient operation of the economy, the effect of delays today compound over decades. As a result, the effective present-day value of an infrastructure project is reduced significantly for larger projects and greater delay in implementation.... That is,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

The Economic Impact of Canadian P3 Projects (Canadian Centre for Economic Analysis, 2016)

Examining the data, as shown in Figure 17 , we see there is a distribution of delays given financial stress (where claims were used as a proxy for financial stress) with different bond types. Non-bonded companies experiencing financial stress would conservatively have projects facing the largest delay distribution. Similarly, the percentage of projects with claims have more delays than those without. This provides:

- A lower estimate of the delays that might be experienced without bonds; and
- The delays that might be avoided for projects that become bonded.

Figure 17 Impact of financial stress on project overruns



What this shows is that:

- Most projects are completed around the expected timeframe, though less so for those being undertaken by companies with under financial stress (i.e., with claims); and
- While roughly 90% of projects not under financial stress (i.e., without claims) are completed within a 40% delay, a similar proportion of those under financial stress (i.e., with claims) are only completed within a 200% delay.

Note that we are not assigning any specific reason for the change in total time from expectation. Projects may extend beyond their initial target date for a variety of reasons – such as scope changes or unforeseen issues – in addition to financial issues, hence overruns for projects without claims as well.

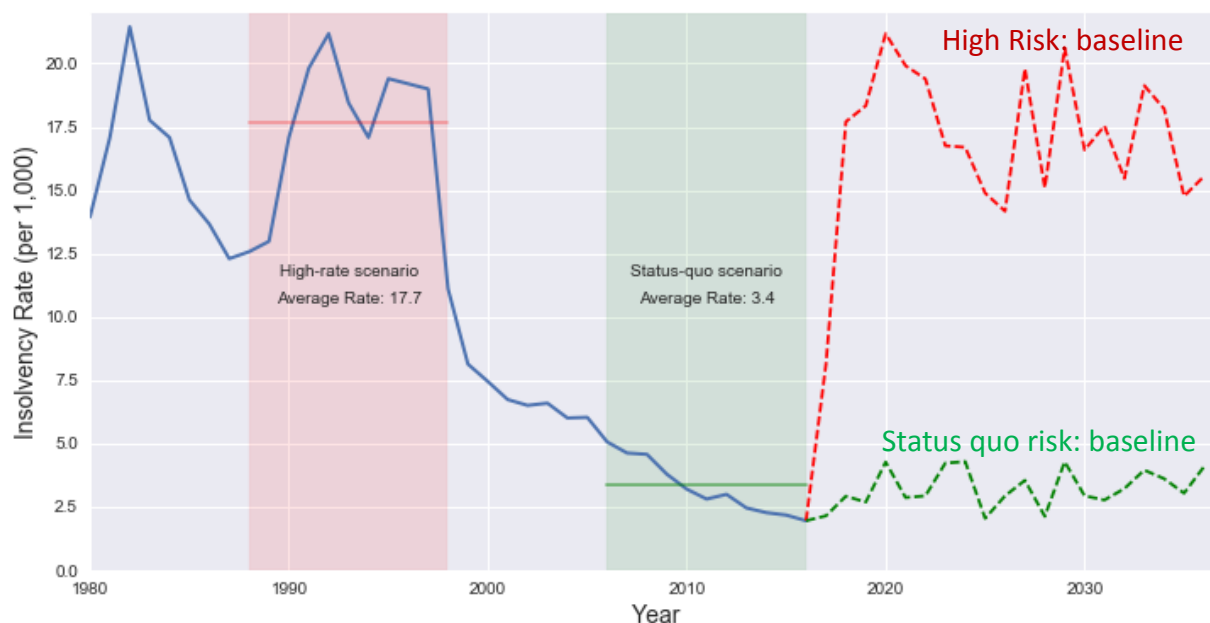
3.1.3 DISTRIBUTION OF PROJECTS AND BOND PROPERTIES

Project values range from tens of thousands to multi-million dollars with the majority in the \$100,000 to \$1,000,000 range. Note that project values are “annualized” by dividing total value by expected duration of construction (in years), as this is more reflective of the rate that money enters the economy. The model picks bond properties based on the distributions from the SAC dataset, and premiums may vary depending on bond type (performance vs performance and payment). This gives us a way of randomly selecting realistic bond characteristics in the simulations.

4. RESULTS

Beginning with the baseline, or reference scenario, against which the impacts of surety bonds will be measured.

Figure 18 Baseline insolvency rates in the construction sector



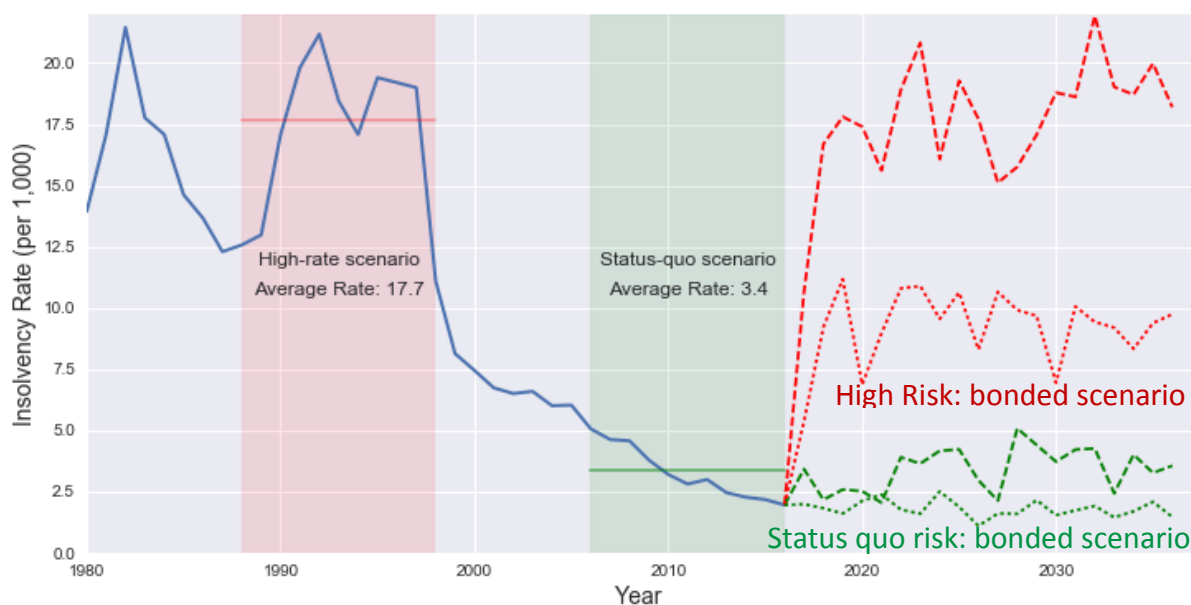
In Figure 18 :

- The dashed green line shows a typical modelled rate of insolvency in the status-quo scenario with no surety bonds; and
- The dashed red line shows a typical modelled rate of insolvency in the high-rate scenario with no surety bonds.

Now, consider a specific *example* in which all public infrastructure capital projects are eligible for bonds and are bonded, no minimum project threshold is applied, and all bonds can have characteristics randomly drawn from the characteristics seen in the SAC data. For example:

- The percentage of project value covered is randomly drawn from the “Bond Coverage” distribution (usually 50% or 100%); and
- The premium paid relative to the original bond is randomly drawn from the “Premiums” distribution.

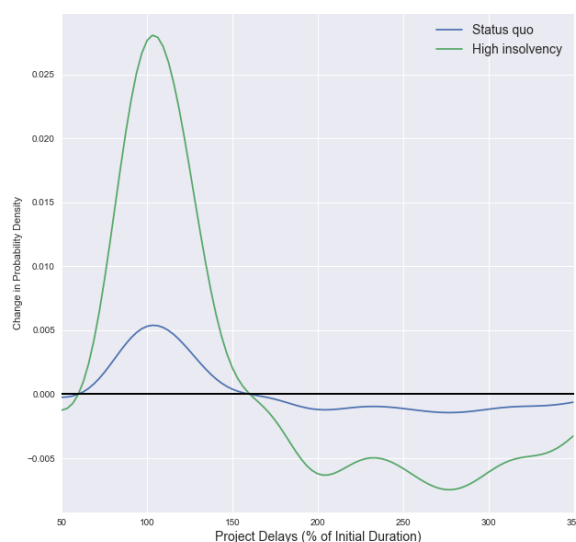
Figure 19 Scenario insolvency rates in the construction sector



As shown in Figure 19, with performance and payment bonds, insolvency rates are reduced considerably (shown is the case when 100% of infrastructure projects have bonds). In the high-insolvency scenario, there is significantly more room for improvement, and as such, we see a significant decline in insolvencies. This results in much larger economic benefits overall.

Further, companies that become insolvent lead to project delays – directly if the company is the general contractor or indirectly if a supplier becomes insolvent, such as through the insolvency of a different customer. (These are modeled based on the distribution of project delays with claims.) By introducing the performance and payment bonds, however, we see a significant reduction in delays – as shown in Figure 20. As a result, many more projects are completed closer to the scheduled time with a large decrease in the number of projects with large overruns, particularly in the high risk case.

Figure 20 Change in delay distribution



The economic contribution due to project delays and compounding effects are significantly greater in the high-insolvency scenario. This is largely driven by the bigger aggregate portfolio of projects delayed at higher insolvency rates. Similar differences exist for the other outcome metrics such as tax revenue and jobs.

Figure 21 GDP impact of all public infrastructure having performance and payment bonds

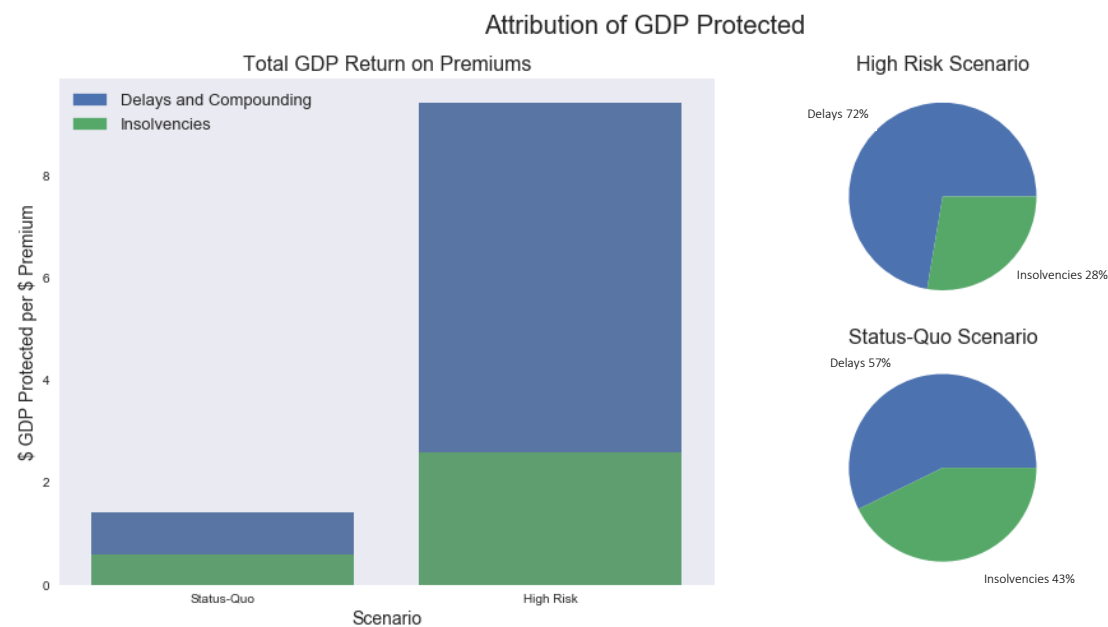


Table 1 highlights that the high insolvency risk case is disproportionately large. That is, the status quo risk case is driven more by direct insolvencies while the high-risk case more by the network effects.

Table 1 Summary economic impacts of surety (public infrastructure)

Risk level	Economic activity, per \$1 of premium	% of benefits arising directly from reduced insolvencies	Associated tax revenue, per \$1 of premium
Status Quo	\$1.4	43%	\$0.4
High risk	\$9	28%	\$2.7

As a demonstration of the importance of both bond types, Figure 22 and Figure 23 highlight the economic impacts as a percentage of the scenario maximum for public infrastructure only (Figure 22) and for all capital projects (Figure 23) in the high-risk scenario. That is, inclusion of both bond types (performance and payment) for projects leads to better economic outcomes than performance bonds only.

Figure 22 GDP impacts as % of high risk-scenario, public infrastructure only

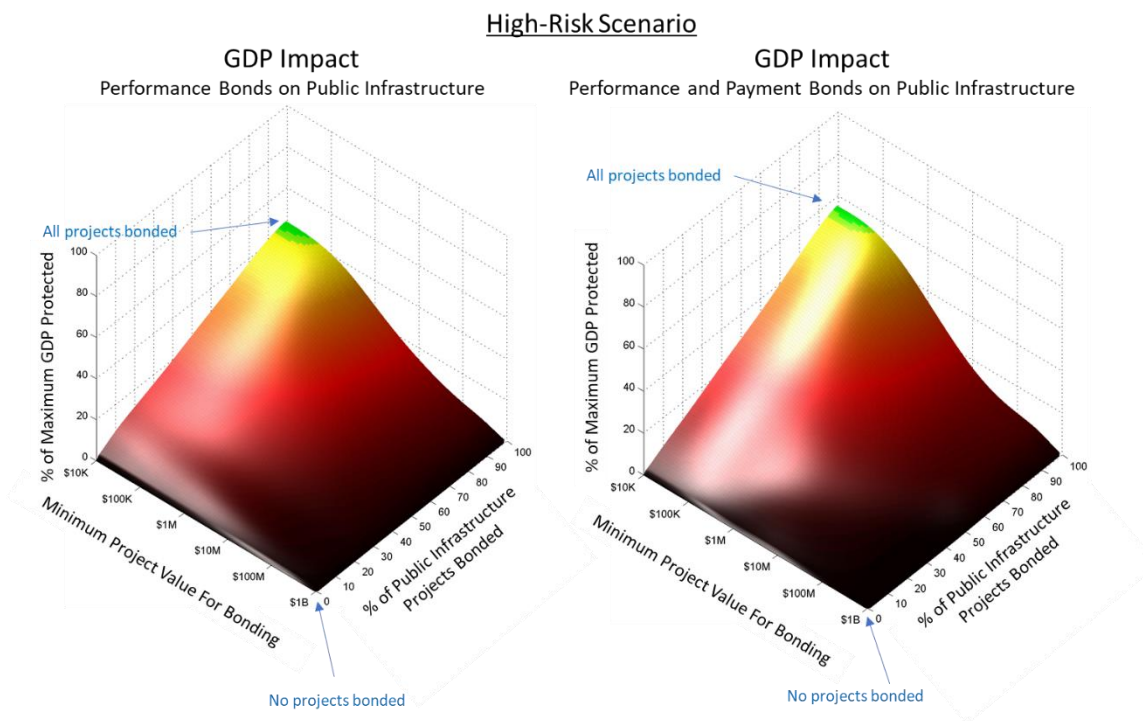
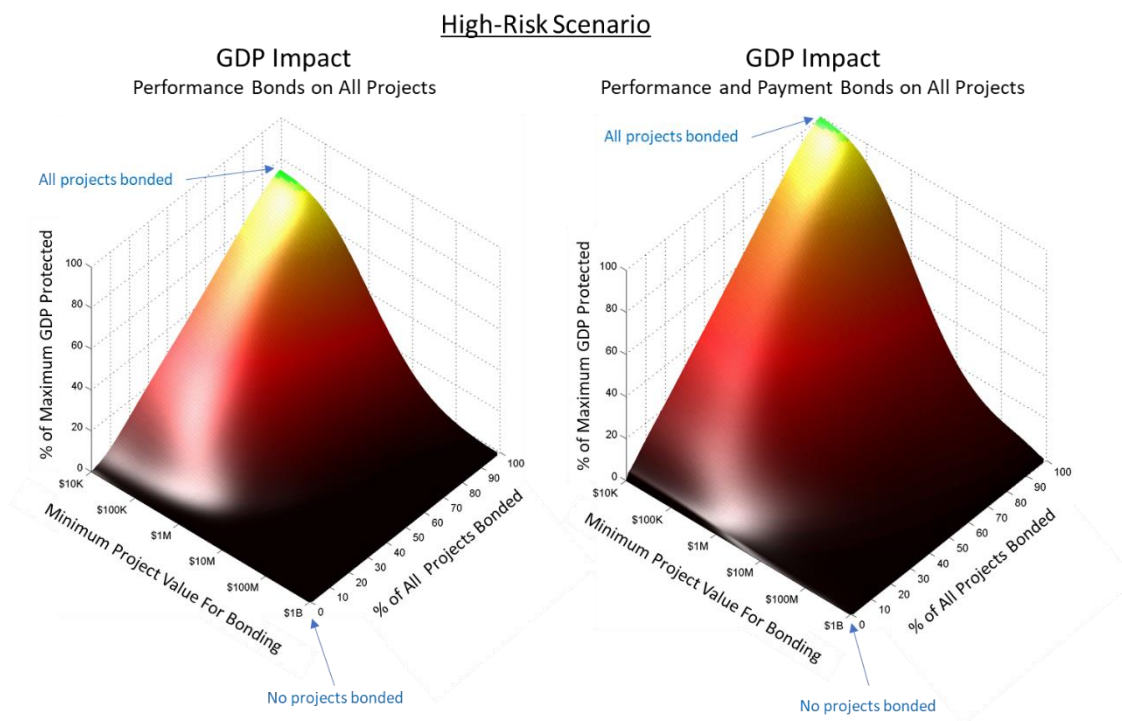


Figure 23 GDP impacts as % of high risk-scenario, all infrastructure



5. CONCLUSION

Credit and operational risk in the construction industry can vary significantly due to the movement of interest rates, recession, supply shocks, debt levels, credit squeezes and so on. Currently, Canada enjoys historically low rates of construction insolvencies, which has been aided in part by the fact that a majority of public infrastructure projects are surety bonded.

By understanding, quantifying and simulating the way in which the construction industry is connected between suppliers and subcontractors of materials and services and to the broader economy, the value of providing surety guarantees for projects to the socio-economic network of British Columbia could be measured. We found that the impact of surety – and the additional due diligence its use ensures – is generally positive, regardless of scenario run (assuming some coverage). But a combination of performance and payment bonds – with a focus on infrastructure investments – yields the highest benefits (measured in terms of GDP growth) relative to the costs required.

The benefits in the high insolvency rate scenario (e.g., 1990's levels) were particularly significant and about 7 times greater than in the status-quo scenario despite the insolvency rates being only 5 times higher. The analysis indicated that the benefits in the high risk scenario include

- \$9 of economic activity recovered per \$1 of premium paid;
- \$2.7 of tax revenue (for all levels of governments) recovered per \$1 of premium paid (by all levels of governments); and
- 63 job-years recovered per \$1M of premiums.

A. DATA SET CHARACTERISTICS

The following table outlines the characteristics of the surety dataset used in the analysis.

Table 2 Characteristics of the surety data set

Characteristics	Value
Number of Surety Firms	6
Year of Earliest Record	1997 (not all firms provided data back to this date)
Total Number of Project	150,000+
Total Number of Construction Firm Records	10,000+
Total Number of Surety Claims	3,000+

Various firms provided different levels of details for construction firms, projects, and claims.

B. DEFINITIONS

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: 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)

Beneficiary: A person who is entitled, by law or bond language, to claim against a bond even though they may not be specifically named as an obligee.

Bid bond: An instrument which guarantees that a bidder, if awarded the project, will execute a contract for the amount bid and will provide the appropriate performance and payment bonds.

Collateral: Assets (e.g., cash) which is placed with the surety company and reduces the risk that the surety assumes when issuing a bond for high risk principals or unusual obligations.

Commercial surety bonds: Bonds that guarantee the performance of all obligations that do not arise from contracts.

Contract surety bonds: A classification of bond that guarantees the principal's obligations under a construction contract.

Obligee: The party to whom a service will be provided, and to whom a surety bond guarantees the service provider will perform as expected.

Payment bonds: Also known as "labour and materials bonds", a classification of bond that guarantees payment by a contractor to subcontractors, labourers, and suppliers involved in contracted project.

Performance bonds: A classification of bond that guarantees performance of the contract. The obligee will be protected from financial loss resulting from the principal's failure to perform the work according to the contract, plan, and specifications at the agreed price. Most of these contracts are for construction, and the contractor must meet pre-qualification standards before being approved for the bond.

Principal: The bonded party (e.g., contractor) who bears primary responsibility on a surety bond and who has the duty to perform for the obligee's benefit.

Prosperity at Risk®: An event-driven, agent-based, microsimulation platform that tracks over 50 million agents for all of Canada. 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.

Surety (company): The party to a surety bond who answers to the obligee for the principal's failure to perform as required by the underlying contract, permit, or law.

Surety bond: A written contract in which one party guarantees another party's performance to a third party. Protects the obligee against losses, up to the limit of the bond, that result from the principal's failure to perform its obligations or undertaking. Unlike insurance, a loss paid under a surety bond is fully recoverable from the principal.

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.

Systemic risk: In the context of this report, "systemic risk" refers to risks that are inherent to an entire market segment as well as the wider macroeconomic framework.

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