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Estimating the impacts on GDP of natural disasters in Canada

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Introduction

Extreme weather events contribute to increased volatility in both economic activity and prices. This interferes with efforts to identify the true underlying trends in the economy. With this in mind, a timely examination of the impact of natural disasters on Canadian gross domestic product (GDP) is necessary to ensure monetary policy can respond appropriately during these periods.

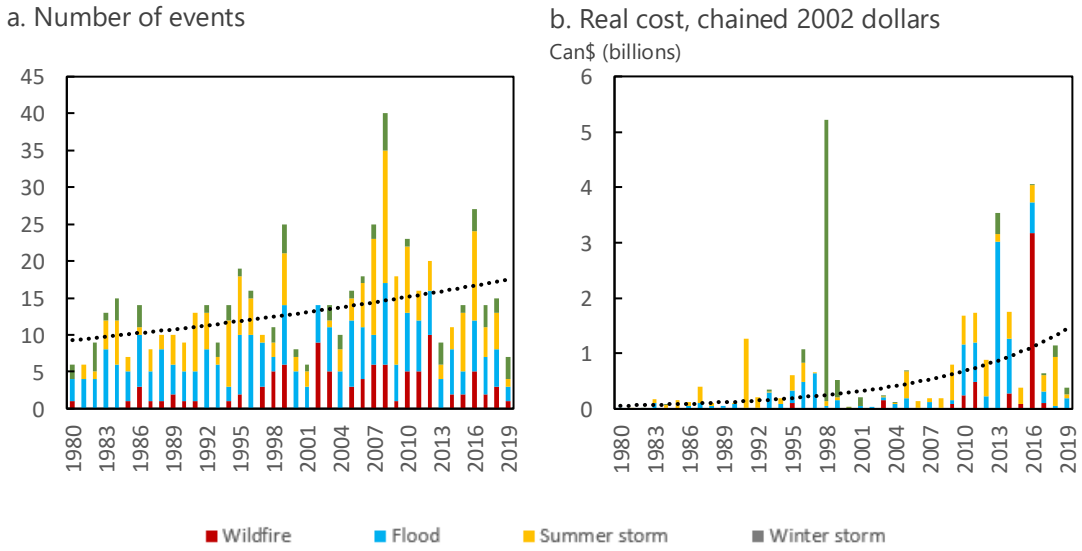
Analyzing the impacts of natural disasters across Canada on GDP, we find that provincial and federal government measures play a crucial role in shaping the overall GDP response following a disaster. As well, the effects of multiple disasters occurring simultaneously can accumulate and further contribute to volatility in Canada's GDP.

This paper is part of a broader series examining the macroeconomic effects of natural disasters, including their impact on inflation (Duprey and Fernandes, forthcoming) and employment (Duprey, Jo and Vallée 2024).

GDP, natural disasters and fiscal capacity

To measure GDP response after natural disasters, we combine data on monthly provincial economic activity with a dataset of natural disasters from Duprey, Jo and Vallée (2024) covering the period of 1980–2019. The dataset builds on the Canadian Disaster Database compiled by Public Safety Canada (2024) and clearly shows that the frequency and severity of natural disasters have been increasing since 1980 (**Chart 1**).

Chart 1: Frequency and cost severity of natural disasters in Canada since 1980



Note: Real cost includes insurance costs and federal assistance programs. Storms include thunderstorms, hurricanes and tornadoes; floods include storm surges. Dotted lines show the trend.
Sources: Duprey, Jo and Vallee (2024); Public Safety Canada; and Bank of Canada calculations

The effects associated with these disasters can ripple through the economy, leading to widespread macroeconomic consequences. Damaged infrastructure, disruptions to industries and the displacement of populations can all impede economic growth and stability. However, the extent of these impacts does not solely depend on the severity of the event itself. Other factors play a role:

- The responses of provincial and federal governments in supporting effective disaster relief and rebuilding efforts—which often rely on fiscal policies—are critical in aiding the recovery and mitigating the broader economic impacts.
- Private insurance can also help mitigate the impacts of disasters by providing financial compensation to individuals and businesses. It also reduces the financial burden on governments and supports consumer spending through payouts, promoting faster recovery and economic stability after natural disasters have occurred.

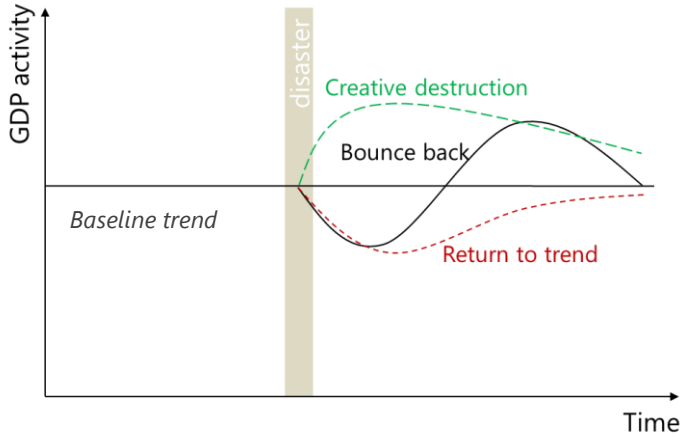
Both private insurance and federal aid are important in disaster recovery, but their roles have shifted over time. Initially, federal aid was the primary support for communities, covering uninsured losses and providing funds for recovery. However, the increasing frequency and cost of natural disasters have led to a greater emphasis on private insurance as a key source of immediate recovery funding. Private insurance now plays a more substantial role by enabling faster payouts, which help stabilize communities more rapidly. Federal aid, meanwhile, now focuses on filling gaps for the underinsured or responding to large-scale losses (see, for example, Davlasheridse and Miao 2019; Ballesteros, Useem and Wry 2017). However, private insurance in high-risk areas may become unaffordable or unavailable as rising disaster costs lead insurers to increase premiums or withdraw coverage (Kousky 2019).

How GDP might respond

The GDP response to a disaster can take many forms. **Figure 1** illustrates three different scenarios.

- **"Bounce back" scenario:** GDP initially declines due to disrupted economic activity, for instance due to destroyed capital, injuries or loss of life. But this is then followed by a surge as resources flow into the affected areas to support recovery, with economic activity rebounding in sectors such as construction and transportation. For example, the number of building permits spiked after the 2016 Fort McMurray wildfires; similarly, rail traffic increased following the 2021 British Columbia floods.
- **"Creative destruction" scenario:** The rapid deployment of aid stimulates an immediate, robust response—such as the hiring of firefighters—and leads to a stronger overall recovery, ultimately boosting GDP.
- **"Return to trend" scenario:** If recovery efforts are weak, prolonged negative impacts result, keeping GDP below pre-disaster levels for an extended period.

Figure 1: Possible GDP response scenarios after a disaster



Note: Figure is based on and adapted from Hsiang and Jina (2014).

To investigate the dynamics in these scenarios, we analyze the response of provincial GDP after various disasters in Canada using a local projection framework (Jorda 2005; see the **Appendix** for more details). Our analysis investigates the impacts over 18 months to assess how quickly economies recover and whether they experience sustained growth effects.

Understanding the influence of government actions is essential to forecasting GDP responses and designing policies that can mitigate the economic fallout of future disasters. A growing body of literature suggests that economies with higher levels of public debt are more likely to suffer sharp declines in growth and tend to recover more slowly after a major natural disaster (see, for example, Bayoumi, Quayyum and Das 2021; Cevik and Tovar Jalles 2023). The literature argues that post-disaster investment growth is generally weaker in economies with higher debt—reflecting their weaker fiscal capacity—making borrowing more difficult to provide immediate relief and restore damaged infrastructure. In this light, we collect debt information from provincial[1] fiscal tables (Department of Finance Canada 2023) and convert it to a monthly provincial debt-to-GDP ratio as a proxy for provincial fiscal capacity (see **Chart A-1** in the Appendix).

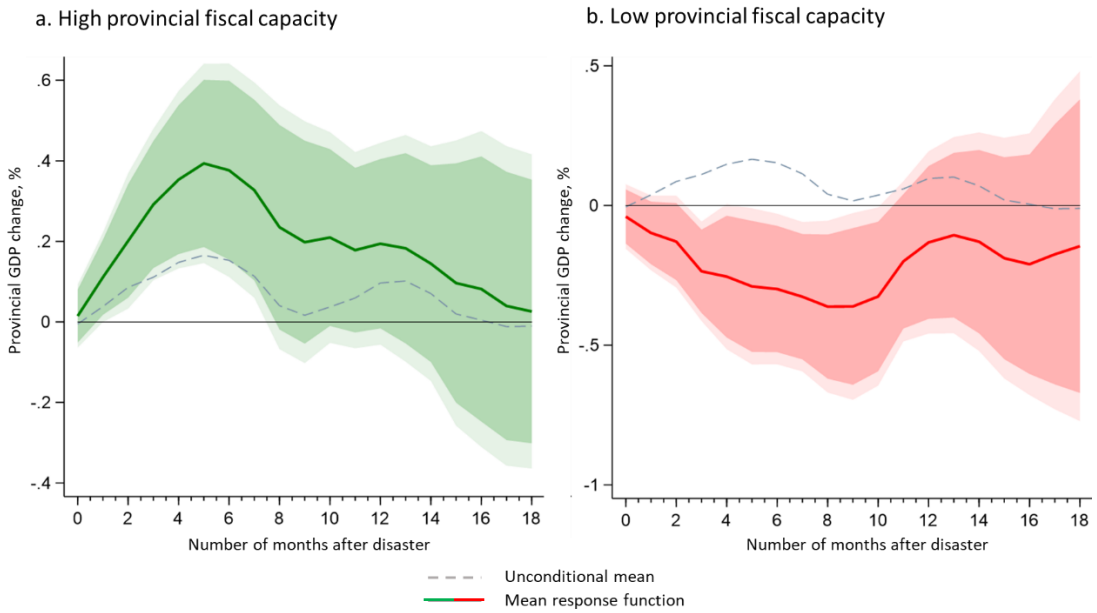
GDP response after a natural disaster is negative when fiscal capacity is low

If we ignore a province's fiscal capacity, we find a small positive effect on GDP after a disaster (**Chart 2**, dashed line in both panels). The post-disaster reconstruction effect dominates, on average.

[1] To be consistent with the data on natural disasters, we collect fiscal data for only the 10 provinces.

However, a province's level of fiscal capacity does play a role in GDP response after a disaster. When fiscal capacity is high (**Chart 2**, panel a), the GDP response is positive. This supports the hypothesis that sufficient aid is available to support relief and recovery efforts in this environment, and the benefits of these efforts outweigh the costs of the disaster. Conversely, the GDP response is negative after a disaster when fiscal capacity is low (**Chart 2**, panel b), suggesting these provinces struggle to provide enough aid following disasters.

Chart 2: Post-disaster GDP response, dependent on fiscal capacity



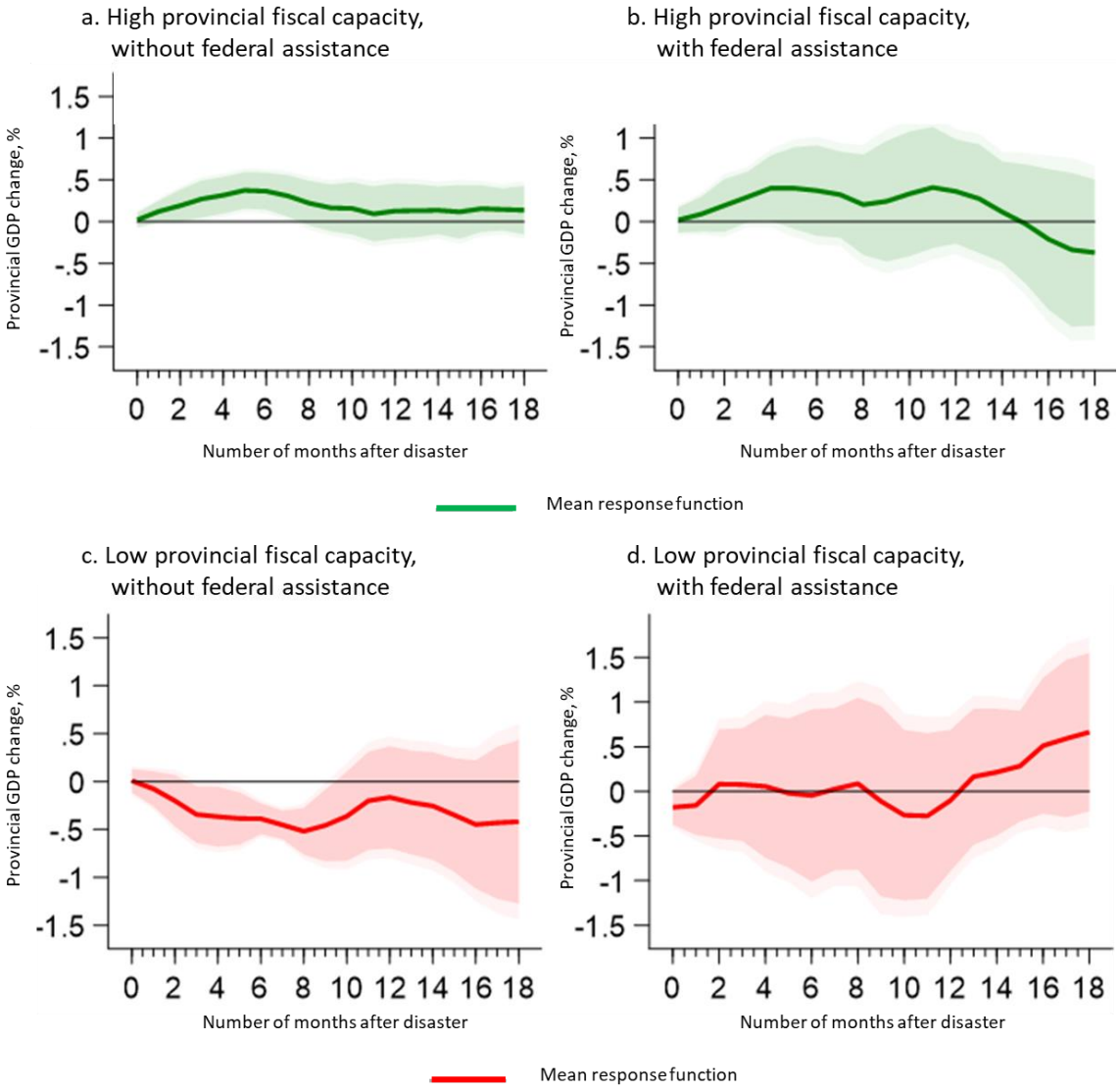
Note: In both panels, the darker shaded areas represent the 90% confidence intervals; lighter shaded areas represent the 95% confidence intervals. All outcome variables are observed at the province level and modelled as differences between the indicated horizon ($t + h$) and the period before the disaster ($t - 1$), when the disaster occurs at period t.

Federal aid can soften negative impacts on GDP

A key mechanism for the federal government to transfer aid to provinces is through the Disaster Financial Assistance Arrangements (DFAA) program. The DFAA provides financial aid when costs exceed the levels that individual provinces could reasonably bear on their own.

When incorporating DFAA payments in our analysis, we see they have little effect on the post-disaster GDP response when a province's fiscal capacity is high (**Chart 3**, panels a and b). One possible explanation for this is that a province can support the recovery efforts on its own, and additional funding from the federal government has little impact on the local economy. However, when provincial fiscal capacity is low (**Chart 3**, panels c and d), federal aid eases the negative post-disaster GDP response. This supports the argument that federal aid is essential to smooth the GDP impacts when provinces alone cannot bear the recovery costs.

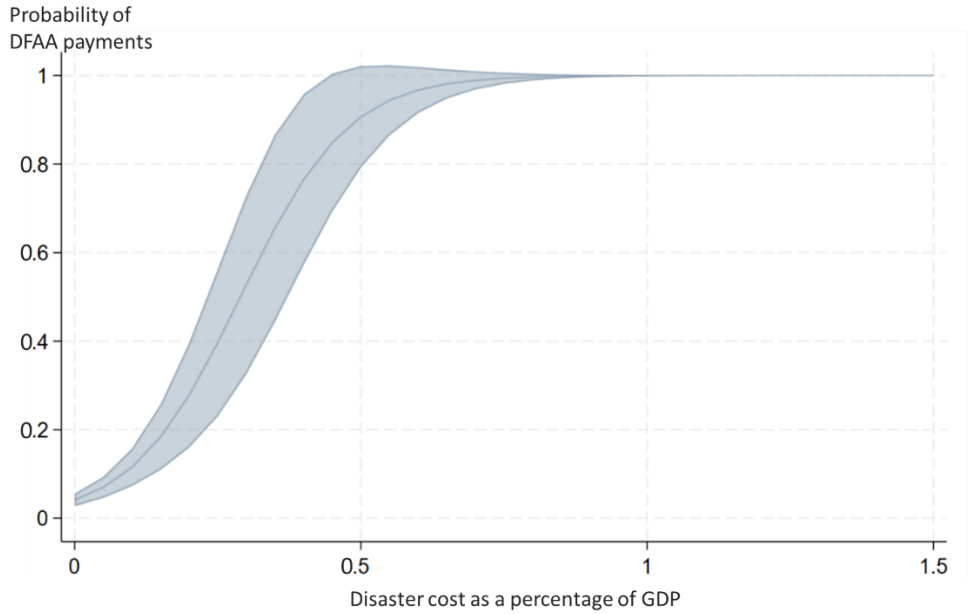
Chart 3: Post-disaster GDP impact, by fiscal capacity and federal assistance



Note: In both panels, the darker shaded areas represent the 90% confidence intervals; lighter shaded areas represent the 95% confidence intervals. All outcome variables are observed at the province level and modelled as differences between the indicated horizon ($t + h$) and the period before the disaster ($t - 1$), when the disaster occurs at period t.

However, federal aid is not a certainty. Historically, the correlation between the severity of the disaster and the likelihood of DFAA payments has been positive (**Chart 4**). For example, the correlation would suggest that DFAA payments were a certainty during the 2016 wildfires in Fort McMurray, Alberta—and indeed, they were granted. However, federal aid can go to provinces after less severe events, suggesting that other factors influence decisions on DFAA payments. It is important to note that factors beyond disaster severity influence DFAA decisions, including a province's ability absorb the financial impact on its own.

Chart 4: Relationship between disaster severity and likelihood of DFAA payments, 1980–2019

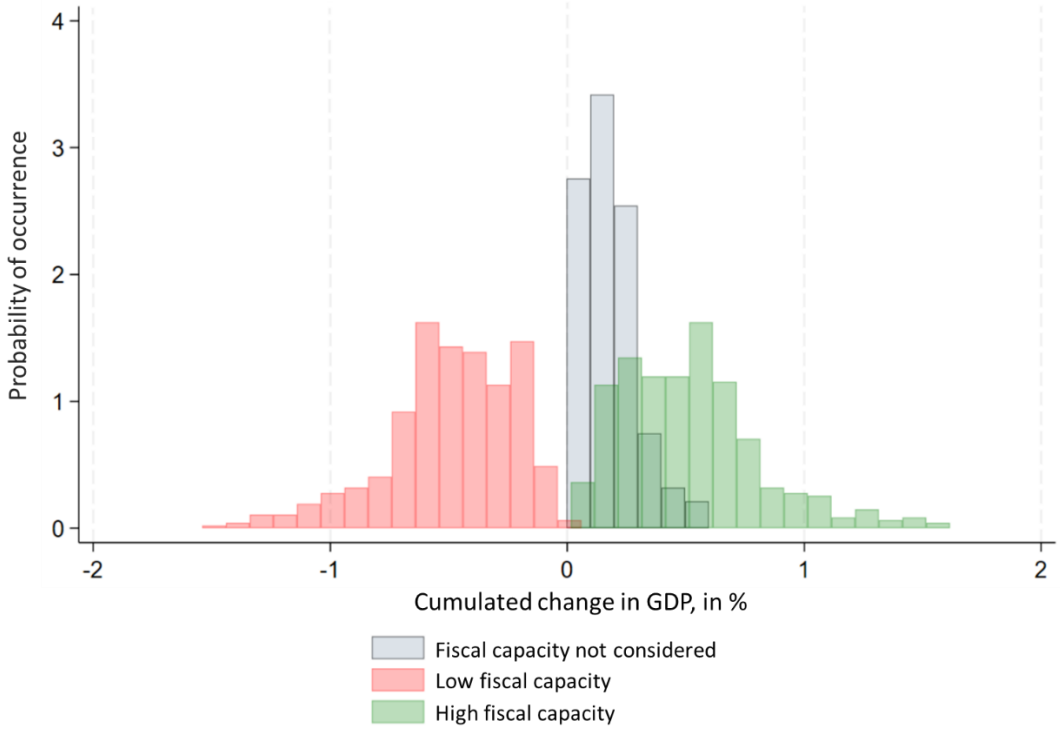


Note: DFAA is the Disaster Financial Assistance Arrangements program.

Nationally, disasters increase volatility in GDP

Multiple natural disasters occur in Canada each year. Their effects can accumulate and contribute to volatility in GDP because the post-disaster GDP response can take months to return to pre-disaster levels. We model and accumulate the impacts of disasters over the past 40 years and see, on average, a small positive effect on national GDP when we ignore provincial fiscal capacity (**Chart 5**, grey bars). However, when we allow provincial GDP responses to depend on fiscal capacity, we see significant volatility in the distribution of the accumulated GDP response. As noted earlier, when fiscal capacity is high, we see positive post-disaster GDP impacts driven by strong relief and recovery efforts. This can lead to a large positive accumulated impact of up to 1.5% on national GDP (**Chart 5**, green bars). Meanwhile, when there is no federal aid, we see an accumulated large negative impact on national GDP of up to -1.5% (**Chart 5**, red bars).

Chart 5: Average accumulated impact on national GDP from disasters in Canada, 1980–2019



Note: A reading of 1 means that, on average, national GDP is 1% higher than usual due to natural disasters. For simplicity, each natural disaster is assumed to have an impact over a maximum of 18 months, the horizon of the impulse responses. The black bars correspond to the effect without considering fiscal capacity. The green (red) bars are counterfactual effects if we instead assume that all provincial economies maintain their highest (weakest) fiscal capacity.
Source: Bank of Canada calculations

Discussion

The findings in this paper highlight the critical role that both provincial and federal fiscal policies play in shaping the GDP response to natural disasters. When provincial fiscal capacity is strong, post-disaster recovery efforts, such as infrastructure rebuilding and emergency aid, are effective at stimulating economic activity, leading to a positive GDP response. This supports the "bounce back" and "creative destruction" response scenarios, where immediate recovery efforts drive a rapid rebound in economic activity. However, in provinces with weak fiscal capacity, the negative impacts of disasters are more pronounced as local governments struggle to mobilize resources for relief and recovery, prolonging economic downturns.

It is important to note that these findings represent the average impact of disasters in Canada, drawing on 40 years of historical data. While useful for understanding broad trends, this average may underestimate the effects of more extreme, rare events, which could have far greater economic consequences.

Federal aid—particularly through programs like the DFAA—emerges as a key mitigator of these negative impacts. Federal aid helps close the gap when provincial resources are insufficient, reducing the economic strain on regions that would otherwise face prolonged negative GDP outcomes. However, the availability and scale of federal aid are not always guaranteed, which introduces uncertainty in the economic recovery. Additionally, a circular issue exists, where more frequent and severe disasters lead to increased debt spending, raising provincial and national debt levels. As debt levels rise, the ability of governments to absorb the costs of future disasters diminishes, exacerbating the economic impacts of subsequent events. This dynamic could further amplify the economic consequences over time, particularly for regions that are already fiscally constrained.

Despite the mitigating role of federal aid, the broader implications of rising government debt due to disaster relief efforts must also be considered. As extreme weather events become more frequent and severe, increasing reliance on government aid could lead to significant debt accumulation, deepening the ongoing debt-disaster cycle. Additionally, the economic consequences of changes in private insurance premiums and coverage availability should be explored further to fully understand the macroeconomic effects of natural disasters in Canada.

Appendix

The state-dependent local projection model for GDP and natural disasters

We establish a general model of the economic impact of natural disasters using the local projection framework of Jorda (2005). The dependent variable, $y_{i,t+h:t-1}$, is the monthly difference in log provincial GDP between the indicated horizon ($t + h$) and the period before the disaster ($t - 1$), when the disaster occurs at period t:

$$
\begin{aligned}
y_{i,t+h:t-1} = & \sum_{\tau=1}^{3} \varphi_h^{\tau} y_{i,t-\tau} + \mu_y + \mu_m + \mu_i + \mu_{i,m} \\
& + S\left(z_{i,t-1}\right)\left\{c^b + \sum_{d=1}^{4} \beta_h^{d,+} \mathbf{1}_{disaster_{i,t}^d} + \alpha_{i,t}^{d,+} cost_{i,t}^d + \sum_{d=1}^{4} \gamma_h^{d,+} DFAA_{i,t}^d\right\} \\
& + \left(1 - S\left(z_{i,t-1}\right)\right)\left\{c^b + \sum_{d=1}^{4} \beta_h^{d,-} \mathbf{1}_{disaster_{i,t}^d} + \alpha_{i,t}^{d,-} cost_{i,t}^d + \sum_{d=1}^{4} \gamma_h^{d,-} DFAA_{i,t}^d\right\} \\
& + \sum_{d=1}^{4} \sum_{\substack{p=-12 \\ p \neq 0}}^{h} \beta_h^{d,p} \mathbf{1}_{disaster_{i,t+p}^d} + \epsilon_{i,t+h}
\end{aligned}
\tag{1}
$$

Equation (1) is estimated using the entire monthly panel of 10 Canadian provinces (indexed by i) for each horizon h = 0,…,18, across all natural disasters of type d {flood, wildfire, summer storm, winter storm}. The main variable of interest is the binary dummy $\mathbf{1}_{disaster_{i,t}^d}$, which denotes the occurrence of a natural disaster of type d, with the corresponding coefficient β_h^d denoting the impact on GDP over time. We also control for the severity of the disaster, $cost_{i,t}^d$, using the estimated disaster cost as a percentage of provincial GDP and whether the disaster in question is accompanied by Disaster Financial Assistance Arrangements (DFAA) payments, $DFAA_{i,t}^d$.

We explore possible public-debt-related state-dependent effects of disasters on GDP using a logistic smooth transition process. Since we are interested in the time variation of fiscal capacity within a province, we further transform this data using a logistic function and evaluate the backward-looking average of the debt-to-GDP ratio, providing a smooth transition variable of a province moving across low and high debt states (**Chart A-1**):

$$
S(z_{i,t}) = \frac{exp\left(\theta \frac{z_{i,t} - c_i}{\sigma_z}\right)}{1 + exp\left(\theta \frac{z_{i,t} - c_i}{\sigma_z}\right)}, \tag{2}
$$

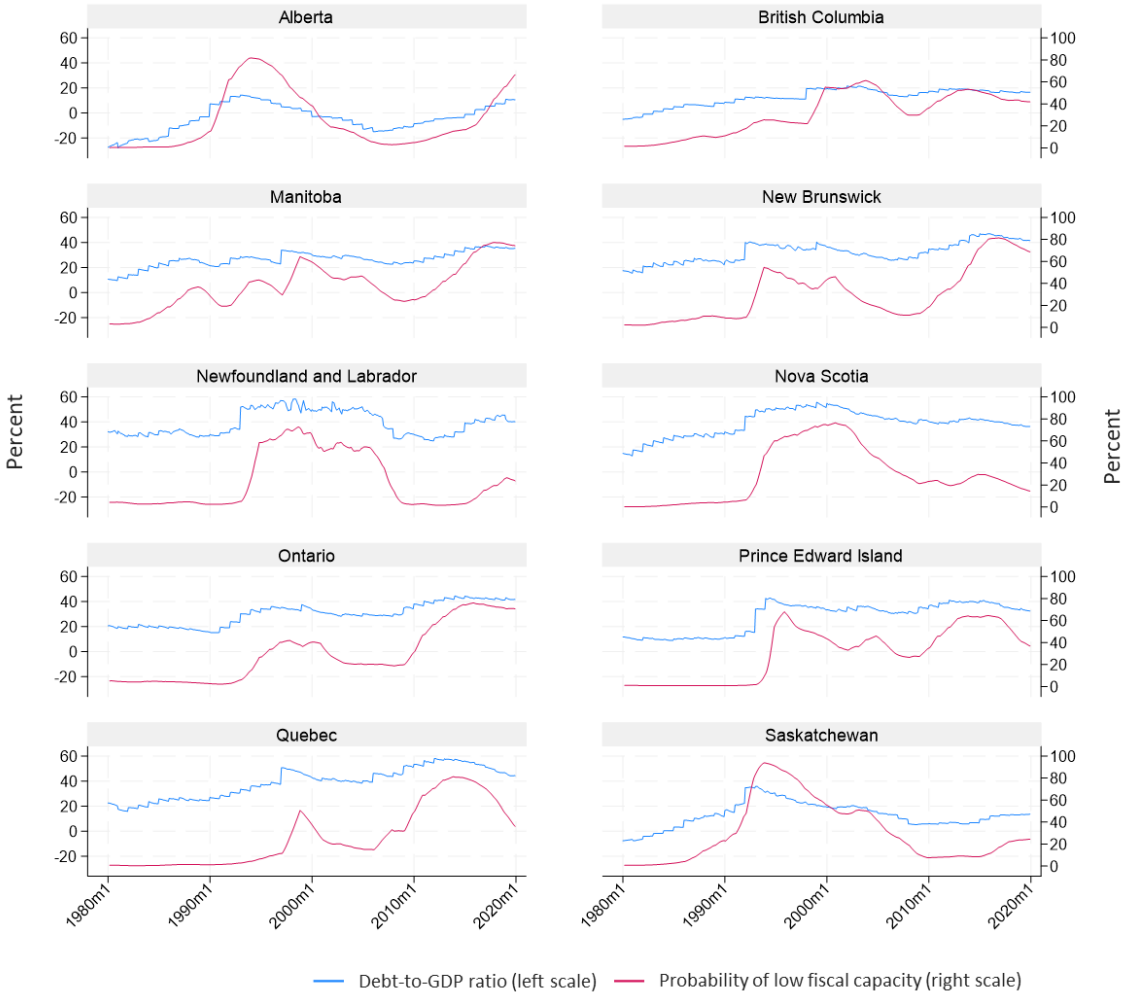
where $z_{i,t}$ denotes the seven-quarter moving average debt-to-GDP level (Auerbach and Gorodnichenko 2012), σ_z is the standard deviation of $z_{i,t}$, and c_i is chosen such that three-quarters of the distribution of $z_{i,t}$ is in the low-debt state. This function can be interpreted as

the probability of being in a given $z_{i,t}$ state, allowing one to uniquely interpret the GDP response to disasters (β_h^d), disaster severity ($\alpha_{i,t}^d$) and DFAA (γ_h^d) across high (+) and low (-) debt states.

Finally, equation (1) also considers the potential impact of other disasters that may have occurred in the months leading up to the disaster of interest (p = -12,...,-1) or between one month after the event and the horizon under investigation (p = 1,...,h). We include three lags of the dependent variable to capture previous provincial economic conditions.[2] To eliminate province-specific influences and any remaining seasonality, we incorporate province (μ_i), month (μ_m) and province-by-month fixed effects ($\mu_{i,m}$). Additionally, we introduce a year fixed effect (μ_y) to account for common changes in economic conditions over time. Our analysis employs heteroskedasticity-robust standard errors.

[2] We chose three lags to strike a balance between capturing the persistence of economic shocks and avoiding overfitting.

Chart A-1: State variables of public finances, 1980–2019



Sources: Department of Finance Canada and Bank of Canada calculations

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