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# Macroeconomic Uncertainty and the COVID-19 Pandemic: Measure and Impacts on the Canadian Economy

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# ABSTRACT

This paper constructs a measure of Canadian macroeconomic uncertainty, by applying the Jurado et al. (2015) method to the large database of Fortin-Gagnon et al. (2020). This measure reveals that the COVID-19 pandemic has been associated with a very sharp rise of macroeconomic uncertainty in Canada, confirming other results showing similar big increases in uncertainty in the United States and elsewhere. The paper then uses a structural VAR to compute the impacts on the Canadian economy of uncertainty shocks calibrated to match these recent increases. We show that such shocks lead to severe economic downturns, lower inflation and sizeable accommodating measures from monetary policy. Important distinctions emerge depending on whether the shock is interpreted as originating from US uncertainty –in which case the downturn is deep but relatively short– or from specifically Canadian uncertainty, which leads to shallower but more protracted declines in economic activity.

JEL Classification: C53, C55, E32.

Keywords: COVID-19 Pandemic, Uncertainty, Forecasting, Factors Models, Vector Autoregressions.

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# 1 Introduction

Many economic decisions represent bets on the future such as when to make large purchases such as cars and housing, when to invest in new plants, equipment and infrastructure or whether to extend credit to entrepreneurs, households and corporations. As such, these decisions require educated guesses about future economic conditions and may be postponed or even abandoned when the outlook for the future becomes harder to assess. An extensive literature has examined the quantitative implications of this intuition, by measuring economic uncertainty in a variety of ways and analyzing the macroeconomic implications of shocks to these measures.[1]

The COVID-19 pandemic has undeniably increased this difficulty to assess the future, both because the severity and infectiousness of the virus is still under study and because the long-term economic fallouts of the various responses to the pandemic are only just emerging. As such the pandemic embodies a very important increase in uncertainty and makes this literature more relevant than ever.

The present paper makes two contributions to this literature. First it constructs the first Canadian measure of macroeconomic uncertainty, by applying the Jurado et al. (2015) method to the large database of Fortin-Gagnon et al. (2020). This measure confirms that Canadian macro uncertainty has indeed increased dramatically recently, with the monthly-frequency version of our measure reaching unprecedented levels. These dramatic increases resemble those obtained with data from other countries or using other methodologies to measure uncertainty (Leduc and Liu, 2020a; Baker et al., 2020; Altig et al., 2020).

Second, the paper uses vector autoregressions (VARs) to compute the likely macroeco-

[1]Important papers in this literature include those from Jurado et al. (2015), who measure uncertainty through the performance of a forecasting model applied to a large database; Baker et al. (2016), who use the frequency at which expressions similar to 'economic policy uncertainty' appear in media; Bloom (2009), who identifies uncertainty with measures of volatility on financial markets, or Leduc and Liu (2016) who employ answers to future-oriented questions in the *Michigan Survey*. See Fernandez-Villaverde and Guerron-Quintana (2020) for a survey of this literature.

nomic implications of uncertainty shocks similar in size to the observed COVID-induced levels. Considering the position of Canada as a small open economy tightly linked with its American neighbour, we analyze both the consequences of shocks to US uncertainty and to its Canadian counterpart, taking care to identify and control for the possible spillovers between these measures.

We show that such shocks lead to severe economic downturns, lower inflation and important accommodating measures from monetary policy. Important distinctions emerge, however, depending on whether the uncertainty shock is interpreted as originating from the US or from specifically Canadian sources: in the former case, downturns caused by the shocks are deep but relatively short while in the latter, declines in economic activity are less pronounced but more persistent. We show that these results are qualitatively unchanged under alternative assumptions about the ordering (identification) of the VARs or differencing of the data.

Several very recent papers analyze the COVID-induced spikes in uncertainty and assess their likely implications for the growth rate of output (Baker et al., 2020), unemployment and monetary policy (Leduc and Liu, 2020a), economic agents' expectations about the future (Dietrich et al., 2020) or the adoption of labour-saving technology (Leduc and Liu, 2020b), among several topics. These result add to the existing, pre-COVID literature establishing that increases in uncertainty lead to declines in economic activity and increases in unemployment (Bloom, 2009; Jurado et al., 2015; Caldara et al., 2016; Baker et al., 2016; Leduc and Liu, 2016; Carriero et al., 2018).

However, the great majority of research on uncertainty and its macroeconomic impacts has been conducted with US data and, when other countries do appear in this literature, the analysis usually pertains to the effect of US uncertainty on the foreign country (Colombo, 2013; Klssner and Sekkel, 2014; Kamber et al., 2016).[2] The present paper

[2]An exception is Moore (2017), which examines the domestic impacts of Australian uncertainty.

therefore constitutes the first contribution that specifically documents the interrelated movements between Canadian uncertainty, its US counterpart, and Canadian economic activity. Considering the severity of the economic downturn caused by the pandemic and the difficult road ahead towards recovery, our results are timely and policy-relevant.

The remainder of this paper is structured as follows. Section 2 describes the Jurado et al. (2015) method to measure macroeconomic uncertainty while Section 3 presents our Canadian application of this method. Section 4 compares our measure to alternatives obtained using data from other countries or other methodologies. Section 5 presents our main findings about the likely macroeconomic impacts of the recent increases in uncertainty. Section 6 concludes.

## 2 Measuring macroeconomic uncertainty

A simple intuition underlies Jurado et al. (2015) (JLN hereafter)'s measure of macroeconomic uncertainty : the economic future is more difficult to predict when uncertainty is high; conversely, uncertainty is lower when predicting future economic outcomes becomes relatively easier.

JLN operationalize this intuition by measuring uncertainty as the general performance of a forecasting model. To this end, they apply a factor-based approach to a large database containing dozens of macroeconomic time series. They compute forecasts, forecast errors, as well as the conditional volatility of these forecast errors, for each individual time series in the database and for every time period. Macroeconomic uncertainty at a given point of time is then defined as the weighted sum of all individual conditional volatilities in forecasting errors.

Specifically, let $y_t^j$ be the value at time $t$ of the $jth$ time series of the database and $\widehat{y^j}_{t+h}|I_t$ the forecast of $y_{t+h}^j$ obtained using information known as of period $t$, with $h$ the forecasting horizon. The conditional volatility in the forecast error at horizon $h$ for time series $j$ at time $t$ is

$$U_t^j(h) = \sqrt{E\left[\left(y_{t+h}^j - \widehat{y^j}_{t+h}|I_t\right)^2 |I_t\right]}, \tag{1}$$

where $E\left[y_{t+h}^j - \widehat{y^j}_{t+h}|I_t\right]^2$ represents the variance in the forecasting error conditional of information known at time $t$. JLN's aggregate measure of macroeconomic uncertainty is then defined as

$$U_t(h) = \sum_j^N \omega_j U_t^j(h), \tag{2}$$

where the weights $\omega_j$ are constant across all series in the benchmark analysis, but could be weighted according to alternative criteria. The general measure (2) is flexible and can be specialized in a variety of ways. Notably, the summation can be specific to geography, using data series pertaining to a specific Canadian province, or can be conditional on sectoral criteria, retaining only nominal price and interest rate data, say. Our results below explore both of these avenues.

This paper develops a Canadian measure of macroeconomic uncertainty by applying the JLN method to the database constructed and maintained by Fortin-Gagnon et al. (2020). This database contains more than 300 time series related to the Canadian economy, is available for both quarterly and monthly frequency and is updated regularly. The data begin in 1981, include both national and regional information, and cover various sectors such as production, the labour market, prices and interest rates, housing market activity and trade, among others. As is the norm for large-scale databases, individual time series are treated for seasonality, differenced when relevant and normalized. Note that the quarterly version of the database contains numerous series drawn from Canada's National Accounts, like GDP and its various components; as such it relies on a richer information set than the monthly version. We report uncertainty measures based on both quarterly and monthly data below, but the impact analysis in Section 5 is based on the quarterly version because of this informational advantage.

As indicated above in (1)-(2), measuring macroeconomic uncertainty requires that a general forecasting framework for each individual time series be established. To this end, consider the following factor model for forecasting future values of series $y_j$:

$$\mathbf{X}_t = \mathbf{\Lambda^F} \mathbf{F}_t + \mathbf{u_t}; \tag{3}$$

$$\mathbf{X}_t^2 = \mathbf{\Lambda^W} \mathbf{W}_t + \mathbf{v_t}; \tag{4}$$

$$y_{j,t+h} = \rho(\mathbf{L})\, y_{j,t} + \beta(\mathbf{L})\, \mathbf{F}_t + \gamma(L)\, \mathbf{F}_{1,t}^2 + \delta(\mathbf{L})\, \mathbf{W}_t + e_{j,t+h}. \tag{5}$$

The expressions (3) et (4) first describe how the information contained in the many hundred time series of the database are efficiently summarized. As such, (3) describes how the vector $\mathbf{X}_t$, which contains all the database's variables, is expressed as a linear function of a small number of common factors $\mathbf{F_t}$ and idiosyncratic components $\mathbf{u_t}$.[3] However, the linear form in (3) limits its potential ability to account for possible non-linear links between the variables in $\mathbf{X_t}$; to alleviate this problem, (4) is used to identify a second set of factors, $\mathbf{W}_t$, that are related to the square of the variables in $\mathbf{X}_t$.[4] Overall then, (3) and (4) deliver an efficient synthesis of the information contained in more than three hundred time series through the vectors $\mathbf{F}_t$ and $\mathbf{W}_t$ and the factor loadings $\mathbf{\Lambda^F}$ and $\mathbf{\Lambda^W}$.

Equation (5) then shows how forecasts for the future values of each individual time series $j$ are obtained on the basis of information known at time $t$, represented by lagged values of the factors and of the variable itself.[5] This type of factor-based forecasting paradigm has become a standard in the literature (Stock and Watson, 2006).

Finally, note that the variance of the residuals $\mathbf{u_t}$, $\mathbf{v_t}$ and $e_{j,t+h}$ in the equations above

[3] We use the test from Bai and Ng (2002) to determine the number of factors required to adequately summarize the volatility from $\mathbf{X_t}$.

[4] Gorodnichenko and Ng (2017) use a similar factor model setup and find evidence on volatility factors that are persistent and load particularly on the housing sector.

[5] We use four lags of $y_t^j$ et two each for $\mathbf{F}_t$, $\mathbf{F}_{1,t}^2$ and $\mathbf{W}_t$. Note as well that we add the square of the first element of $\mathbf{F}_t$ in the forecasting equation (5).

are each affected by stochastic volatility so that $e_{j,t+h}$, say, is governed by the process $e_{j,t+h} = \sigma^y_{j,t}\,\epsilon^y_{j,t}$ with $\epsilon^y_{j,t} \overset{iid}{\sim} \mathcal{N}(0,1)$ and

$$\log \sigma^y_{j,t} = \alpha^y_j + \beta^y_j \log \sigma^y_{j,t-1} + \tau^y_j \eta_{j,t},\ \eta_{j,t} \overset{iid}{\sim} \mathcal{N}(0,1), \tag{6}$$

where $\beta^y_j > 0$ indicates that episodes of heightened volatility are persistent. Jurado et al. (2015) argue the assumption of stochastic volatility is important to distinguish between periods where time series are more volatile than usual from episodes where they become intrinsically difficult to forecast.

## 3 A Canadian measure of macroeconomic uncertainty

Figure 1 reports the results of applying JLN's method to the quarterly version of Fortin-Gagnon et al. (2020)'s Canadian database. It depicts the uncertainty measure $U^{CAN}_t(h)$ for the one-quarter, two-quarter, and four-quarter-ahead horizons over the period from 1982 to 2020, with the shaded areas representing Canadian recessions as per *C.D. Howe Institute* dating.

Three general features of uncertainty emerge from the figure. First, uncertainty is always higher for longer forecasting horizons, reflecting the fact that forecasting far away in the future may generally be harder. Second, and conversely, uncertainty is less volatile as the forecasting horizons lengthen, since forecasts converge to their unconditional values: this is particularly noticeable for the measure based on four-quarters-ahead forecasts. Third, the various measures are nonetheless very correlated with each other (correlation coefficients between them are all higher than 0.98) and negatively correlated to the business cycle : all three measures increase simultaneously during the early-1990s and 2008 recessions, as well as during episodes of milder turbulences, such as those caused by the 2001 crash of the technology bubble or the late 2014 plunge in oil prices. In addition, all three measures are significantly and negatively correlated with HP-detrended GDP.

Figure 1 also reveals the impact of the COVID-19 pandemic: all three uncertainty measures record sharp increases near the end of the sample and, as of 2020Q1 (the last data point used by our computations), uncertainty is nearly as high as levels attained during the early 1990s recession. Considering that the pandemic's impact on the Canadian economy was in full swing starting March 2020, incorporating data from 2020Q2 is likely to exacerbate that rise. Below we show that indeed the March 2020 readings for the uncertainty measures based on the *monthly* frequency version of Fortin-Gagnon et al. (2020) display unprecedented increases.

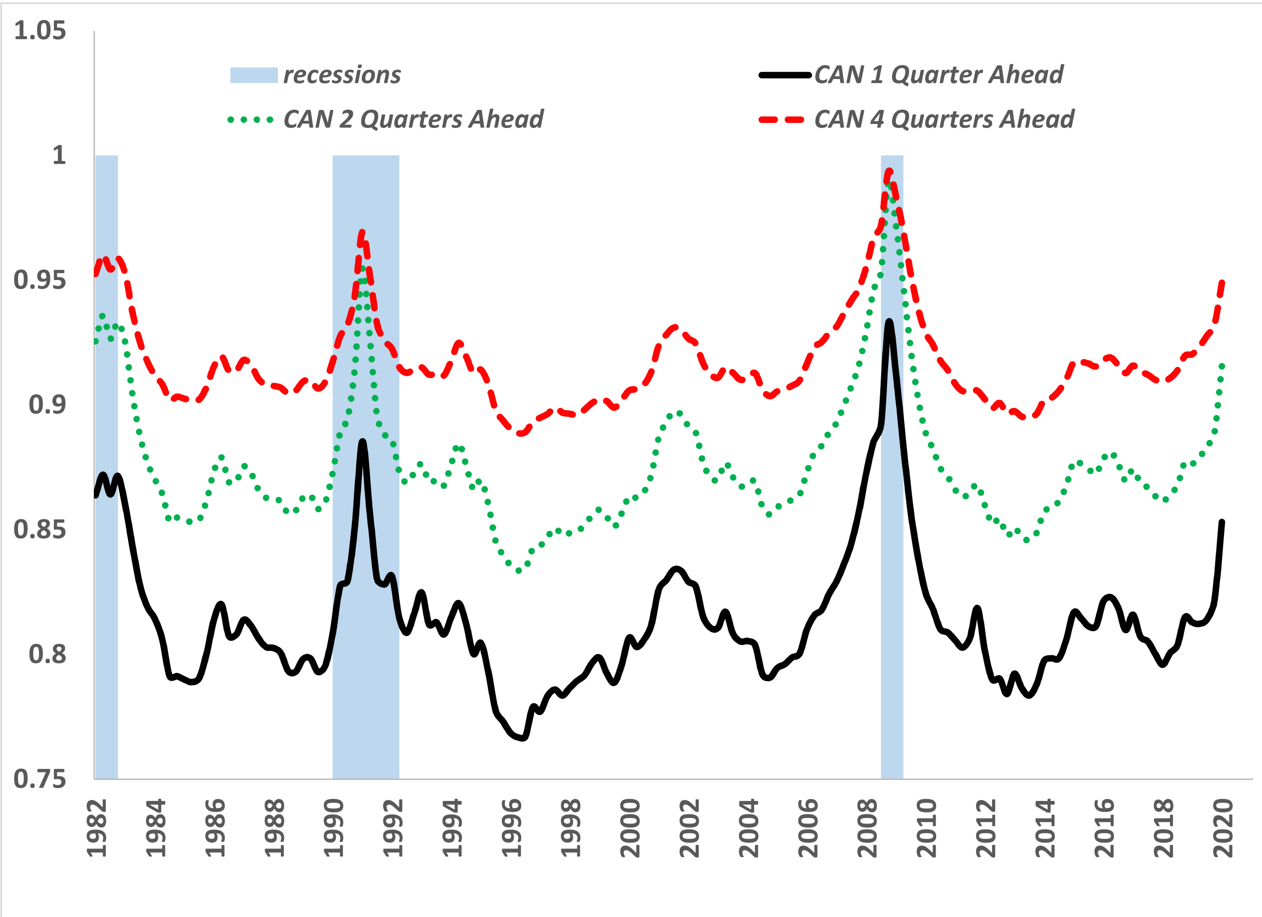
As mentioned above, the construction of uncertainty can be specialized, by conditioning on geographic or sectoral aspects of the data underlying the forecasting model. In that context, Figure 2 compares the evolution of uncertainty obtained using provincial data only (Quebec, Ontario and Alberta) with the overall Canadian measure discussed so far, for the period 2000-2020. The measures in Figure 2 are normalized – we subtracted their respective means and divided by their standard errors– to facilitate the comparison.[6]

Figure 2 reveals that the various provincial measures examined are significantly correlated to overall Canadian uncertainty (correlation coefficients are 0.75 for Alberta and Quebec and closer to 0.80 for Ontario). Interesting distinctions appear nevertheless; notably, the measures for Quebec and Alberta appear to have been less affected by the 2008-2009 period of upheaval than that for Ontario or Canada; conversely, the Quebec measure has increased much more dramatically at the onset of the COVID-19 episode.

Next, Figure 3 shows how conditioning on the broad sector of economic activity can uncover different facets of uncertainty, as well as provide clues about the likely sources for its fluctuations. To do so, the figure once again depicts the evolution of the overall

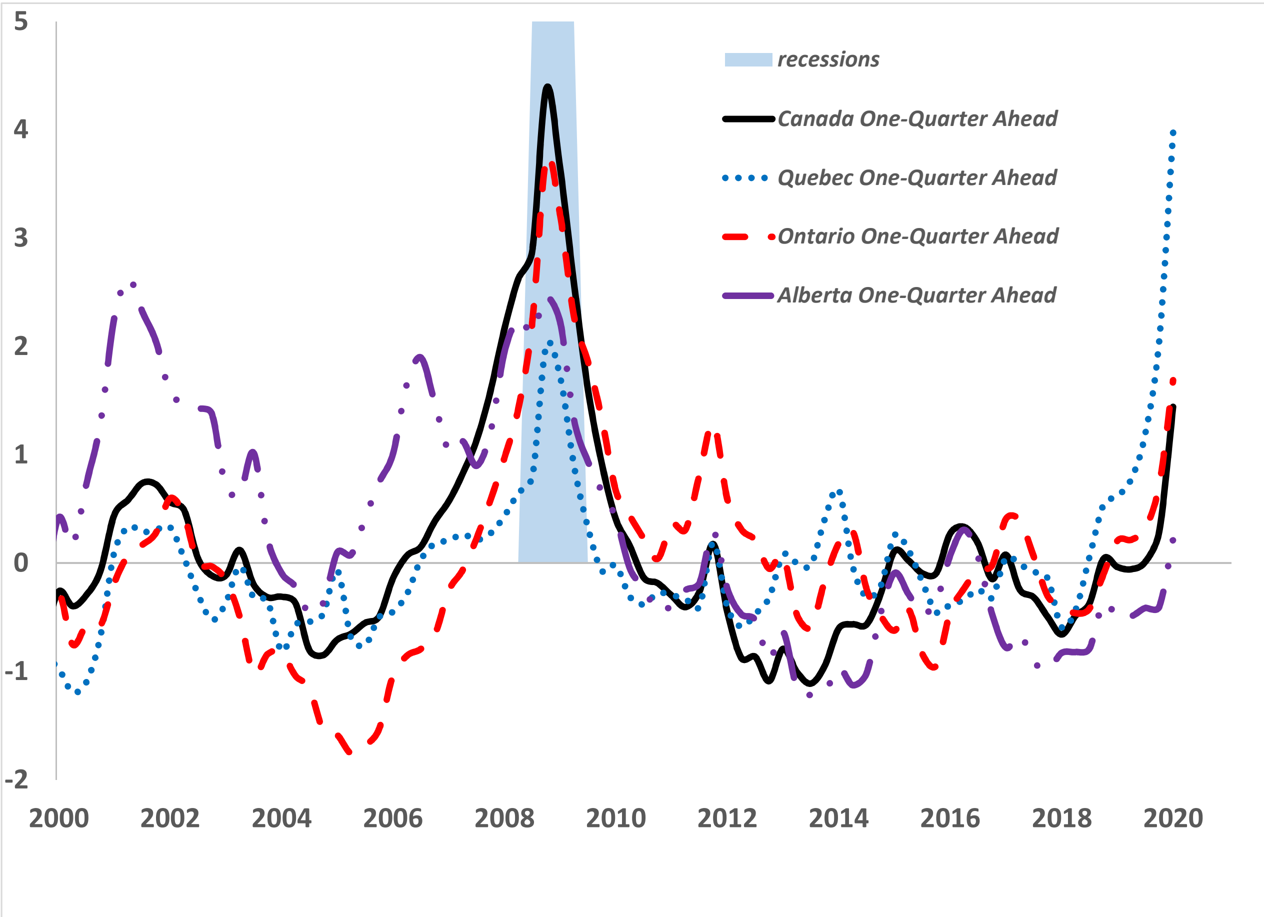
[6]Note that provincial data for GDP and its components are not available for Alberta, which makes data coverage less comprehensive for this province. Uncertainty measures for other provinces may be computed although the number of time series specific to some provinces is limited.

Figure 1: **Canadian Macroeconomic Uncertainty**




measure for Canada alongside three alternatives: the first, labelled *Production Sector* is constructed from (1)-(2) using data series related to (real) GDP and its components, such as capital formation, exports and imports or manufacturing orders. The second, noted *Labor Market*, arises from series related to data from the Labour Force Survey (LFS) and other information about the labour market. Finally, the line labelled *Nominal Sector* relates to data on prices, interest rates, exchange rates and credit. Although all series are once again correlated, some contrasts emerge : uncertainty in *nominal* variables increased as much as the overall figure during the 2008-2009 episode while its rise has been relatively

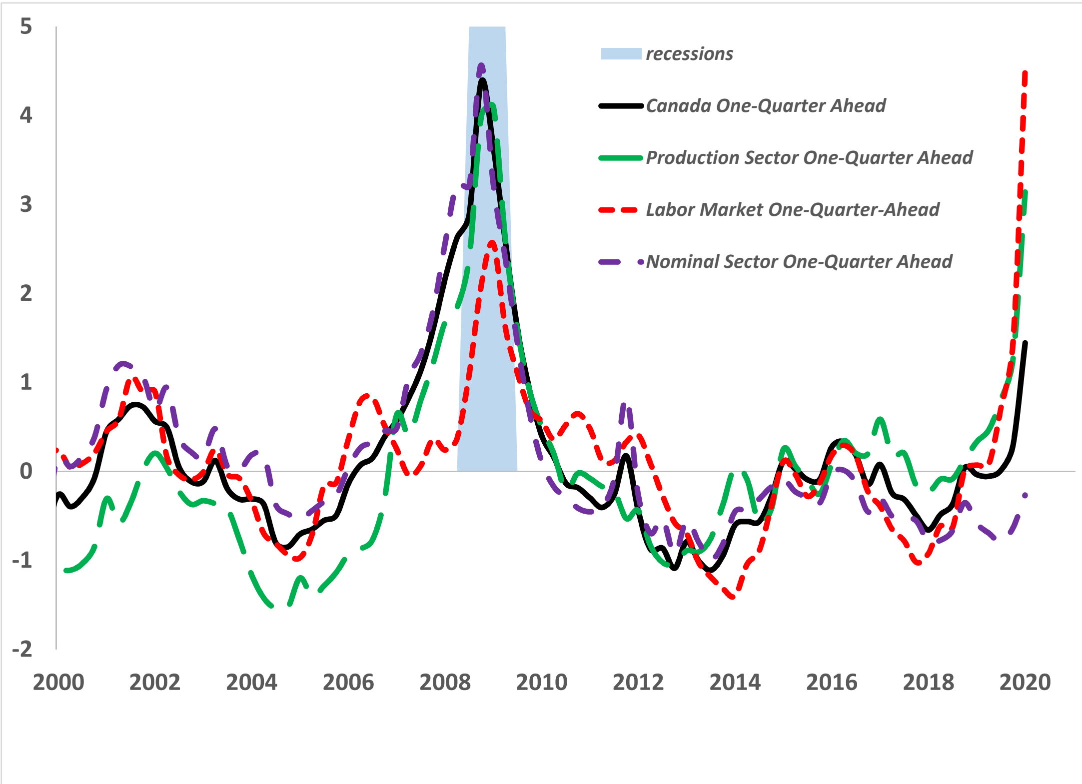
Figure 2: **Canadian Macroeconomic Uncertainty : Provincial Measures**




subdued during the COVID-19 episode; conversely the *Production Sector* and especially the *Labor Market* indices have increased very significantly during the pandemic episode.

Overall therefore, the measure of macroeconomic uncertainty obtained by applying JLN's method to the Canadian database of Fortin-Gagnon et al. (2020) produce series about Canadian uncertainty that are intuitive and can be flexibly adapted to regional or sectoral specificities. The next section compares this measure to those obtained using JLN's method on US data or through the use of different methodologies.

Figure 3: **Canadian Macroeconomic Uncertainty : Sectoral Measures**



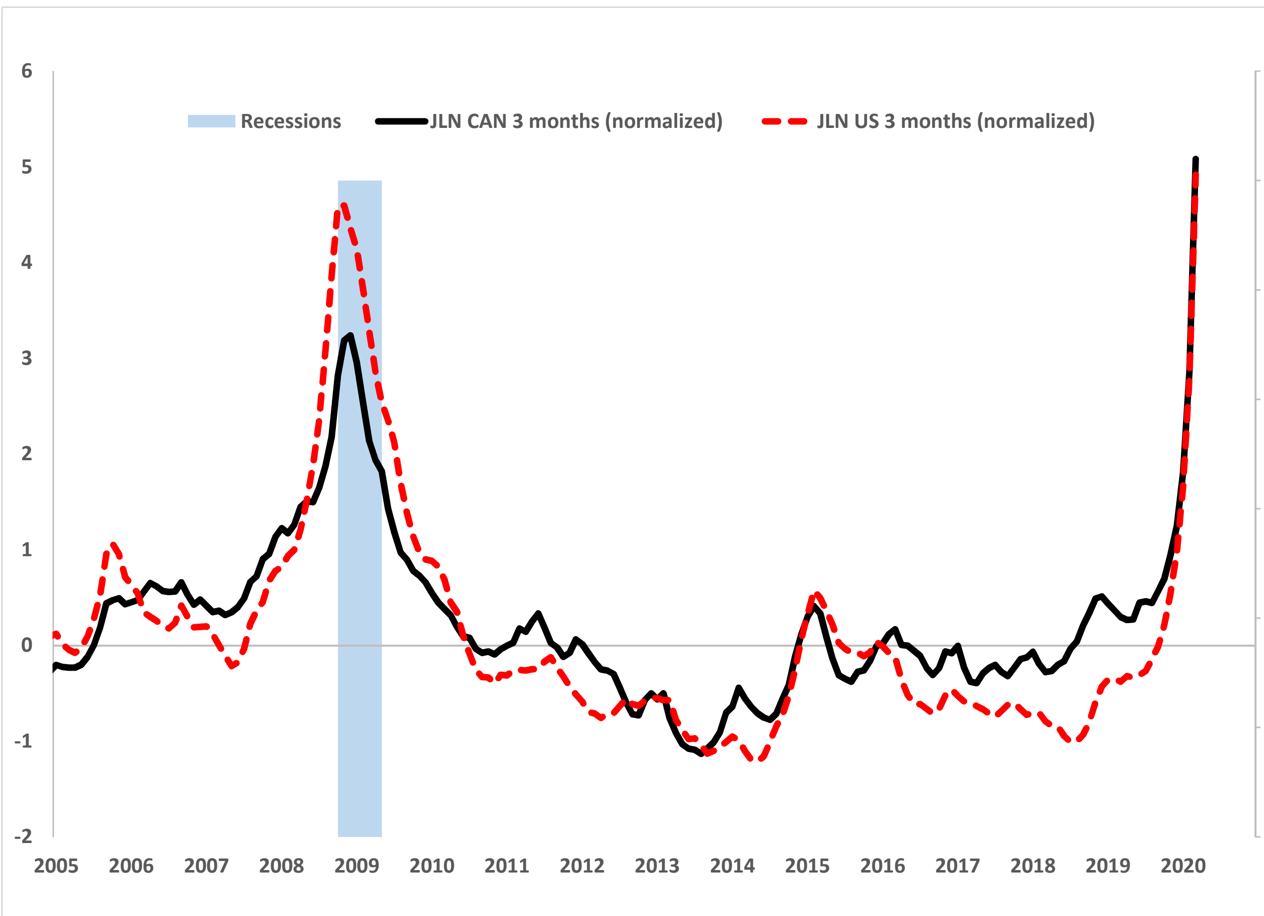

# 4 Comparisons with alternative measures

Jurado et al. (2015) apply their method to U.S. data and their updated measures are available publicly. It is thus interesting to compare the Canadian measure we obtain here with its US-based counterpart. Note that as JLN's measure is based on monthly-frequency data, we reconstruct our Canadian measure by repeating the forecasting exercise (1)-(2) using the monthly-frequency version of Fortin-Gagnon et al. (2020) to facilitate this comparison. Figure 4 reports the results, displaying the *three-months-ahead* measure for both countries since 2005.[7]

[7] As indicated above, the impact analysis of Section 5 employs the quarterly version of our macroeconomic uncertainty measure because of its higher informational content. It is nevertheless interesting to analyze monthly-frequency versions of our measure, which may respond more rapidly to unfolding events.

The figure reports that both measures are highly correlated (the correlation coefficient is 0.87) but that the rise of US uncertainty was higher than the one for Canada during the 2008-2009 financial crisis. The most striking feature of Figure 4 however is the most recent rise in measured uncertainty: for both Canada and the US, these increases bring uncertainty to unprecedented levels, around 5 standard deviations away from their secular average. Section 5 below calibrates uncertainty shocks to match those very significant increases and provide evidence of the likely macroeconomic impacts of such high levels of uncertainty.

Figure 4: **Macroeconomic Uncertainty : Canada versus the US**



As discussed above, two popular alternatives to the macroeconomic uncertainty constructed by JLN are the economic policy uncertainty indexes (EPU), proposed originally by Baker et al. (2016), and measures of volatility in financial markets, as analyzed in Bloom (2009). To provide a comparative view of the similarities and dissimilarities between alternative measures, Figure 5 depicts the evolution of our Canadian measure of macroeconomic uncertainty against these other two measures; as above, all data have been normalized to facilitate the comparisons.

Figure 5: **Canadian Uncertainty : Alternative Measures**

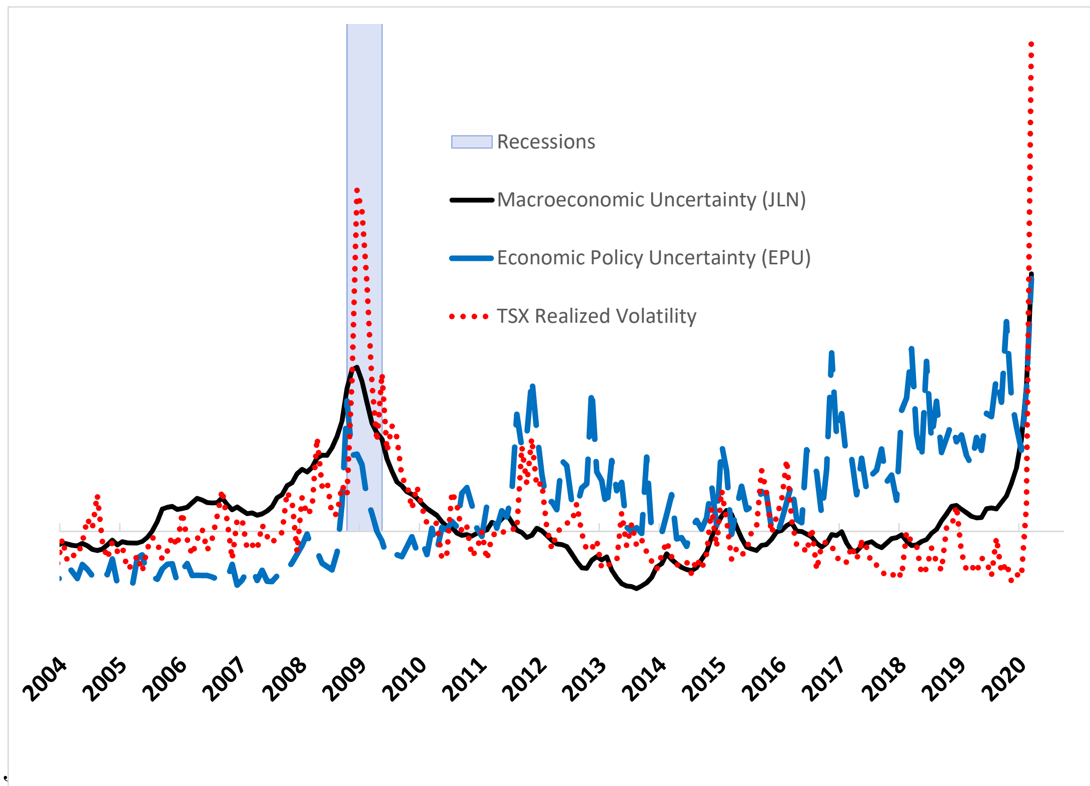



Figure 5 reveals distinct patterns in the evolution of our measure of macroeconomic uncertainty and the two alternatives. Although all three report exacerbated levels during the 2008-2009 financial crisis and the recent COVID-19 episode, both the economic policy uncertainty (EPU) and financial volatility indexes are significantly more volatile and less serially correlated than our measure. This feature, also discussed in Jurado et al. (2015), gives our macroeconomic uncertainty measure a more gradual evolution that is markedly distinct from that of the alternative. Further, the correlation between these alternative measures and ours, while still positive, is significantly smaller than the one that linked the Canadian and US version of the JLN measure above. As such, one may conclude that these three manners to compute uncertainty capture different facets of the phenomenon.

## 5 Macroeconomic Impacts of Uncertainty Shocks

As discussed above, a negative relationship between macroeconomic uncertainty and the business cycle is apparent, both from Figure 1 and from the negative ($-0.3$) correlation between uncertainty and (HP-detrended) GDP. This section discusses how this negative correlation may arise from a causal link whereby shocks to uncertainty lead to decreases in activity and then computes the possible impacts of COVID-induced uncertainty shocks on the Canadian economy.

Bloom (2009) describes how, in a context of heightened uncertainty, firms are likely to postpone or cancel major projects and scale back hiring. In addition, households and consumers might themselves reduce their plans for purchases of durables and housing. Finally, banks may choose to tighten credit availability or its terms. At the economy-wide level, Leduc and Liu (2016) argue that rises in uncertainty constitute decreases in aggregate demand and lead to reduced economic activity, higher unemployment and lower inflation; we now verify that this intuition obtains when analyzing our measure of Canadian macroeconomic uncertainty and the Canadian business cycle.

Our analysis employs structural Vector Autoregressions (VARs) to identify and assess only the impacts of uncertainty shocks. Such methods are used by many of the contributions to the analysis of uncertainty but also in numerous papers examining the impact of monetary policy shocks (Christiano et al., 2005), technology shocks (Gali, 1999) or fiscal shocks (Blanchard and Perotti, 2002) among many others.

In that context, consider the following six-variable VAR

$$\mathbf{Y}_t = \mathbf{A}_1 \mathbf{Y}_{t-1} + \mathbf{A}_2 \mathbf{Y}_{t-2} + \cdots + \mathbf{A}_p \mathbf{Y}_{t-p} + \epsilon_t, \tag{7}$$

where $\mathbf{Y}_t$ contains four key Canadian macroeconomic indicators (GDP, investment, inflation and the term spread) as well as our measure of Canadian uncertainty and the JLN US uncertainty measure. Note that the term spread is included to account for the reaction of monetary policy to shocks: a policy of loosening rates in the wake of an adverse shock –likely to reduce short-term rates more than long-term ones– would thus show up as an increase in the term spread.

The data span the period of 1982Q1 - 2020Q1. Nonstationary variables like GDP, investment and the GDP deflator are transformed in growth rates by taking the first difference of logs. The term spread is the difference between the 10-year government bonds and the 3-month Treasury bond. A complete description of data sources and transformations is available in the appendix A in Table 5. The VAR order is set to 3, according to the Bayesian information criterion.

We use a Cholesky decomposition to identify shocks and as such, the ordering of variables is crucial. For our baseline results, $\mathbf{Y}_t$ is ordered as follows : US uncertainty, Canadian GDP, investment, inflation and term spread and, finally, the quarterly measure of Canadian macroeconomic uncertainty discussed above. This ordering reflects the identifying assumptions that guide our computations of the macroeconomic impacts of uncertainty shocks. US uncertainty is ordered first, reflecting the idea that American macroeconomic developments can affect their Canadian counterparts as well as Canadian uncertainty immediately, while the reverse is not true.

The ordering of Canadian uncertainty is potentially more controversial. One can first interpret uncertainty as an endogenous variable, which reacts to various macroeconomic events and serves as a transmission mechanism for shocks. This interpretation is the one favoured by Ludvigson et al. (forthcoming) and suggests that Canadian uncertainty be placed last in $\mathbf{Y}_t$. Our baseline results reflect that ordering and as such, the shocks to Canadian uncertainty analyzed below cannot, by construction, affect any variables contemporaneously. Placing Canadian uncertainty last in $\mathbf{Y}_t$ has the added advantage of being a conservative strategy, limiting the extent to which fluctuations are attributed to uncertainty shocks.

An alternative vision of uncertainty stems from work by Carriero et al. (2018) and assigns it a more structural and exogenous interpretation, in the sense that innovations to uncertainty are assumed to affect the macroeconomic contemporaneously. As such, this suggests that Canadian uncertainty be placed second in $\mathbf{Y}_t$, just after its US counterpart. We verify that our results are largely robust to this assumption.[8]

### 5.1 Results

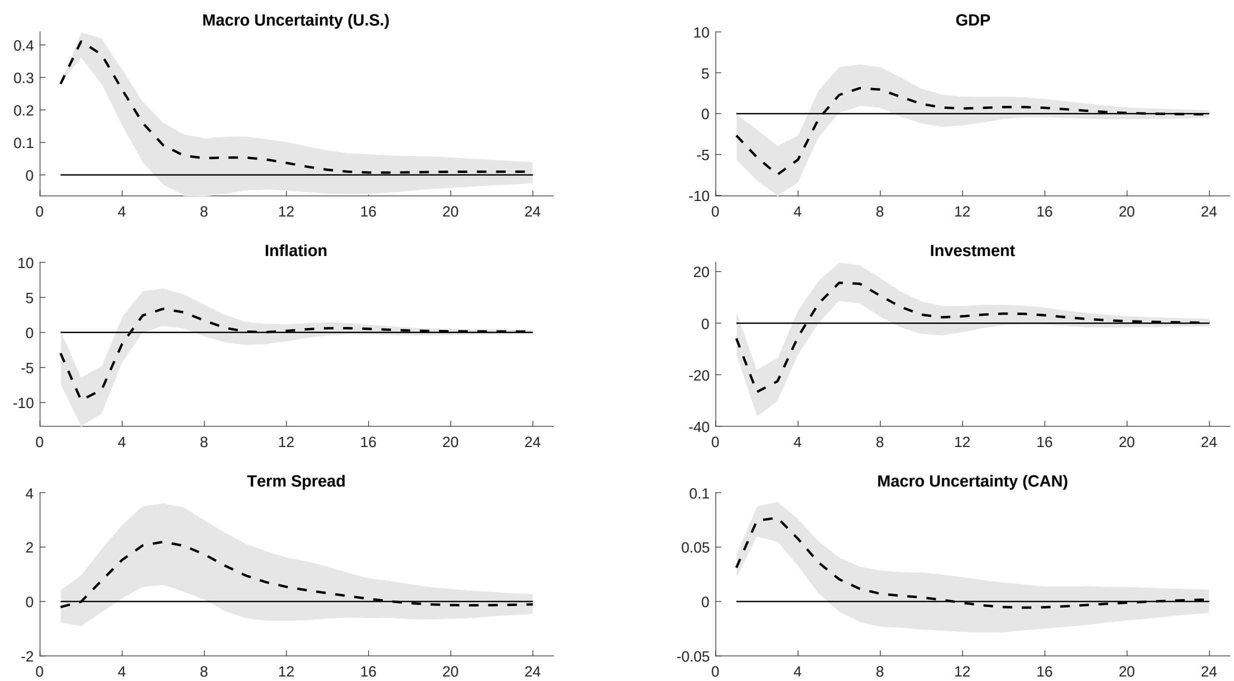
The COVID-19 pandemic constitutes a worldwide event and a first reasonable assumption is that much of the observed increases in both US and Canadian uncertainty are reflections of this global shock. Our first set of results will therefore analyze the impact of a shock to US uncertainty, as a proxy for the global nature of the event. However, one can also argue that the pandemic has affected Canada in specific ways, notably because of the country's reliance on commodity exports or its small-open economy stature. We therefore also analyze the consequences of a Canadian-specific shock to uncertainty.

In this context, Figure 6 and 7 report our baseline results. Figure 6 relates to the responses of the Canadian economy to a US uncertainty shock, whose size has been cal-

[8]Note that the question of to how best to place the uncertainty measure in the VAR does not apply as much to the US measure in our work; whether this variable is endogenous or exogenous to the US economy, it is likely to be exogenous relative to the Canadian economy, which justifies its placement as the first variable in $\mathbf{Y}_t$ for all our experiments.

ibrated to the observed jump in uncertainty that occurred between January and March 2020 and was depicted above in Figure 4. Figure 7 then depicts the impulse response functions following a shock to Canadian uncertainty, calibrated in a similar manner. The shaded areas of both figures represent 90% confidence intervals for the responses, obtained via bootstrapping with 1000 replications.

Figure 6: **Macroeconomic Impacts of a Shock to U.S. Uncertainty**




*NOTES:* Impacts of a shock to US macro uncertainty in a VAR where it is ordered first. Shaded areas represent 90% confidence bands.

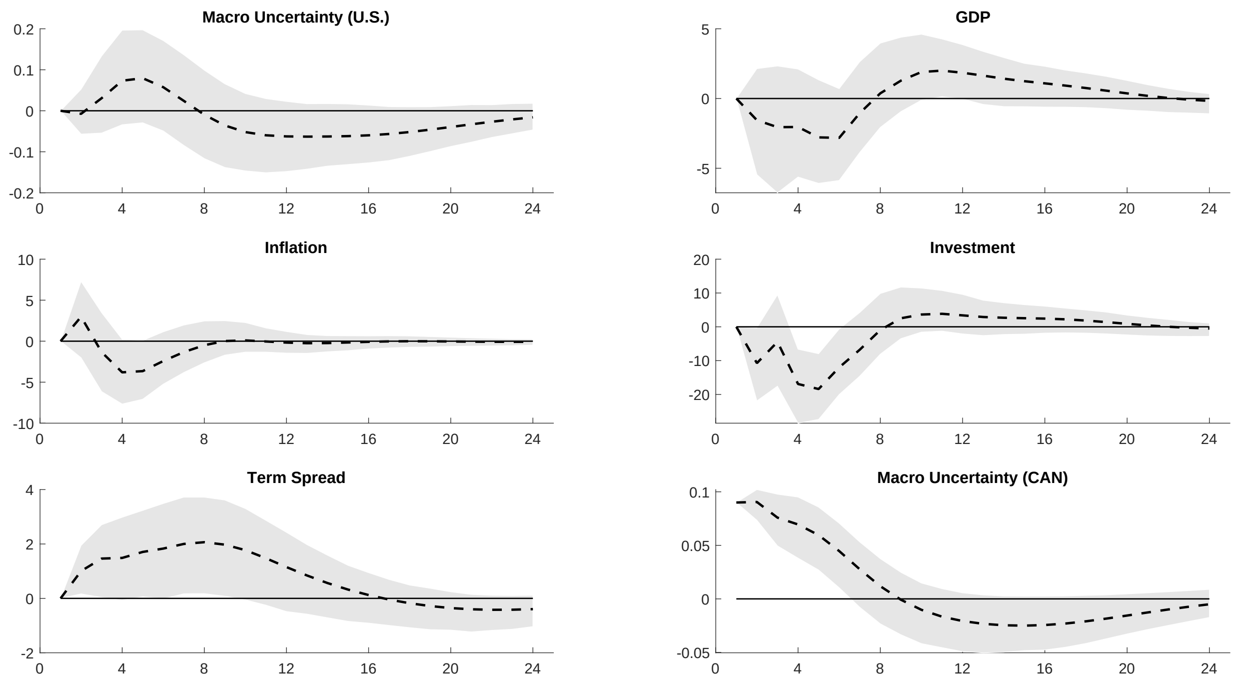
Examine Figure 6 first. As indicated above, it reports the macroeconomic impacts of a positive shock to US uncertainty under the assumption that this shock can affect contemporaneously all other variables –including Canadian uncertainty– but that the reverse is not true. As such, any correlation between Canadian uncertainty and the macroeconomic responses depicted in the figure arise from the simultaneous responses of all these series to the US shock.

Figure 6 shows that a spike in US uncertainty of the order of magnitude recently observed has important negative impacts on the Canadian economy. On the real side, investment and GDP fall by very significant margins, with GDP's decline reaching -7% in the third quarter after the shock, while investment declines by over 20% but bottoms out faster. On the nominal side, inflation decreases very significantly while the term spread increases gradually and remains elevated for a protracted period, indicating persistent loosening interventions by monetary authorities. Finally, the figure shows that spillovers from US (or global) to Canadian uncertainty are sizeable and protracted. Overall Figure 6 suggests that, to the extent the COVID-19 pandemic was responsible for the important recent rise in US macroeconomic uncertainty, the Canadian economy is likely to suffer a severe but relatively short-lived recession, whose negative effects will be attenuated by the response of monetary authorities.

Next, Figure 7 reports the macroeconomic impacts of a positive shock to Canadian uncertainty; in accordance with our identifying assumptions, that shock is orthogonal to movements in US uncertainty, so that the macroeconomic impacts depicted in the figure arise from a purely Canadian event, once spillovers from US uncertainty to its Canadian counterpart have been controlled for. In addition, the ordering of Canadian uncertainty as the last variable in the vector $\mathbf{Y}_t$ implies that this shock has no contemporaneous effects on the VAR's macroeconomic variables.

Figure 7 shows that, although the impacts of the Canadian uncertainty shock are qualitatively similar to those described above, important differences emerge nevertheless. First, the declines in GDP and investment that accompany the shock appear to be less stark but more persistent; as such, the recent shock to Canadian uncertainty is expected to lead to a shallower but more protracted downturn. This contrast could originate from the fact that the US shock constitutes a negative worldwide-level decrease in the demand for many commodities Canada export, while the Canadian shock affects principally non-

Figure 7: **Macroeconomic Impacts of a Shock to Canadian Uncertainty**




*NOTES:* Impacts of a shock to Canadian macro uncertainty in a VAR where it is ordered last. Shaded areas represent 90% confidence bands.

traded production of goods or services, industries that react gradually but durably to shocks.

The visual impression gained from Figures 6 and 7 about the relative impacts of uncertainty shocks on the Canadian macroeconomy are confirmed by examining Table 1. This table reports a variance decomposition outlining how much of the volatility observed in our four macroeconomic aggregates and two uncertainty measures is attributable to US and Canadian uncertainty. The table shows that US uncertainty shocks explain between 20 and 24% of the aggregates' volatility at the relatively short horizons (4 quarters ahead), and that these numbers do not vary considerably as the horizons lengthen towards infinity (the unconditional variance). By contrast, the specifically Canadian shock to uncertainty is found to explain a significantly lower fraction of the aggregates' volatility, but this

Table 1: Variance Decomposition

| Variables | US shock | | | | CAN shock | | | |
|---|---|---|---|---|---|---|---|---|
| | h=4 | h=8 | h=16 | h=24 | h=4 | h=8 | h=16 | h=24 |
| Macro Uncertainty (US) | 93.74 | 80.04 | 66.94 | 65.66 | 0.62 | 1.27 | 2.72 | 3.40 |
| GDP | 19.71 | 20.74 | 20.47 | 20.43 | 0.81 | 1.84 | 2.96 | 3.06 |
| Inflation | 23.07 | 25.39 | 25.47 | 25.49 | 1.58 | 2.76 | 2.75 | 2.75 |
| Investment | 23.65 | 29.08 | 29.19 | 29.19 | 3.64 | 6.71 | 6.87 | 6.91 |
| Term Spread | 3.32 | 13.04 | 14.17 | 13.82 | 2.81 | 6.34 | 9.15 | 9.14 |
| Macro Uncertainty (CAN) | 53.19 | 40.80 | 28.46 | 27.64 | 42.73 | 36.29 | 27.50 | 28.03 |

*NOTES: This table presents the variance decomposition (in %) of the series included in the VAR to US and Canadian macroeconomic uncertainty shocks respectively.*

fraction increases as the horizon increases: for investment, for example, the fraction of variance explained by the Canadian shock notably goes from 3.6% to just under 7.0%

Several robustness checks have been considered and the results are presented in Appendix B. An alternative ordering of the vector $\mathbf{Y_t}$ in the VAR, with the Canadian uncertainty placed second –exogenous to the rest of Canadian variables and in the spirit of Carriero et al. (2018)– does not change the qualitative nature of our results, as shown in Figure 10. The impacts of uncertainty shocks on consumption and labour market indicators are similar to those on GDP and Investment as depicted in Figure 11, with the consumption of durables reacting more than the aggregate measure, as expected. Finally, Figures 12 and 13 plot the dynamic responses when GDP, investment and GDP deflator are kept in levels as opposed to the growth rates employed in our baseline specification.

Recall that two alternative measures of uncertainty, one derived from textual research about the term 'economic policy uncertainty' (EPU) and the other related to financial markets' volatility, have been proposed in the literature and depicted above in Figure 5. These alternative measures can be introduced as the chosen proxies for uncertainty in the VAR (7). Figures 8 and 9 report the responses of the three main macro aggregates to US (Figure 8) and Canadian (Figure 9) uncertainty shocks for the three measures of uncertainty.

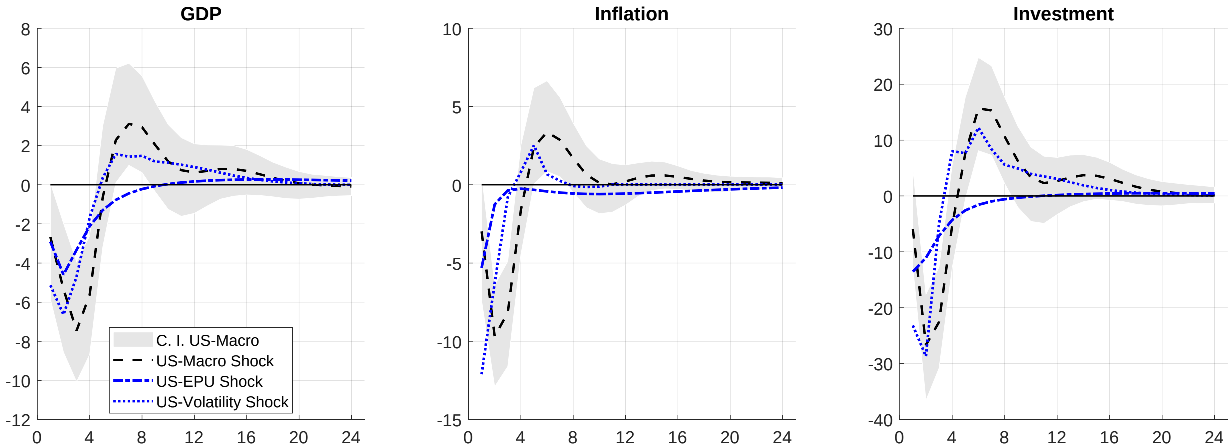
Figures 8 first shows that the aggregates' responses to the US shock are qualitatively similar, with a sudden increase in uncertainty leading to a deep but relatively short-lived economic decline. However, Figure 9 reports that results pertaining to the Canadian shock are not as robust. Notably, while the adverse shock to US financial markets' volatility generated a short-lived but substantial economic slowdown in Canada, the (Canadian) shock to TSX volatility, which controls for the impact of $S\&P500$ volatility, does not generate any important dynamic responses. As such, specifically Canadian shocks to financial volatility have no discernable, unique impact on the Canadian economy, a result in line with those in Bedock and Stevanovic (2017) who report similar contrasts between the effects of Canadian and US shocks when estimating the macroeconomic impacts of credit shocks. This is likely due to the dominant position of the United States in financial markets.

Overall, however, the computed impacts of US and Canadian uncertainty shocks on the Canadian economy are consistent with the interpretation advanced in Bloom (2009) and Leduc and Liu (2016): sudden increases in uncertainty lead firms, households and financial intermediaries to delay or cancel plans, which depresses aggregate demand and leads to declines in economic activity, increases in unemployment and lower inflation.

# 6 Conclusion

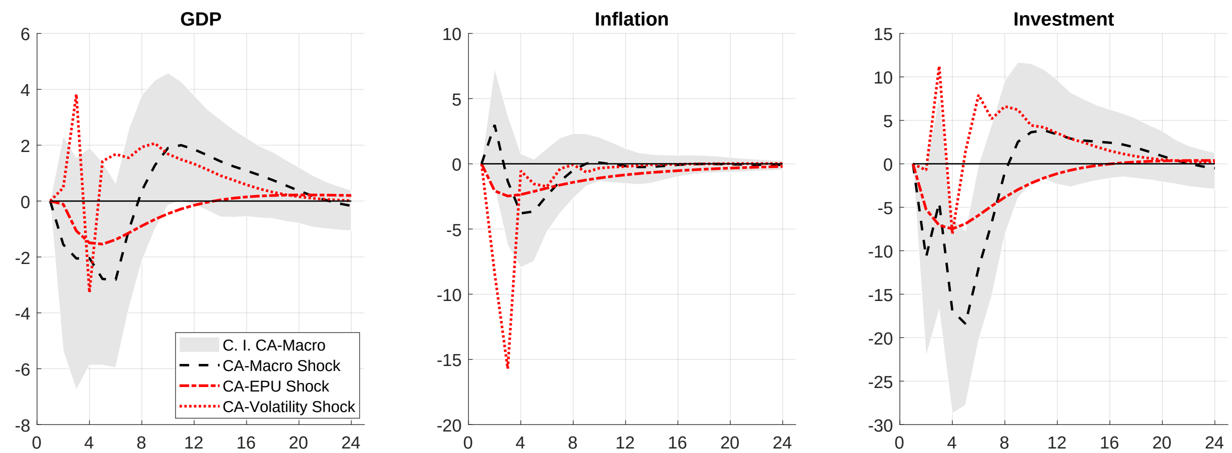
This paper shows that the events linked to the COVID-19 pandemic have led to very sharp increases in Canadian macroeconomic uncertainty, in line with results obtained when using data from other countries or different methods to measure uncertainty. Provided these recent rises in uncertainty have macroeconomic impacts structurally similar to those they had in the past, our VAR analysis indicates that a deep slowdown will affect the Canadian economy for at least the next few quarters and possibly longer. We also show that the macroeconomic impacts of uncertainty shocks are different whether they are assumed to

Figure 8: **Macroeconomic Impacts of a Shock to US Uncertainty: Comparison with Alternative Measures**




*NOTES: This figure compares the baseline IRFs of GDP, Inflation and Investment to shocks on alternative measures of US uncertainty.*

Figure 9: **Macroeconomic Impacts of a Shock to Canadian Uncertainty: Comparison with Alternative Measures**




*NOTES: This figure compares the baseline IRFs of GDP, Inflation and Investment to shocks on alternative measures of Canadian uncertainty.*

affect first US uncertainty or its Canadian-specific counterpart, an interesting contrast that should be the subject of further research. In addition, the question as to whether uncertainty should be a specific input into monetary policy reaction functions remains open.

As the first wave-economic effects of the pandemic are subsiding, analysts and policy makers are now turning their attention to the road to recovery and recent work by Barrero and Bloom (2020) and Foroni et al. (2020) both suggest that this recovery will be very gradual. In this context, the exacerbated state of uncertainty that this paper has uncovered and analyzed will most probably contribute to slow down the return to pre-COVID economic trends and, as such, uncertainty should continue to be monitored by fiscal and monetary authorities.

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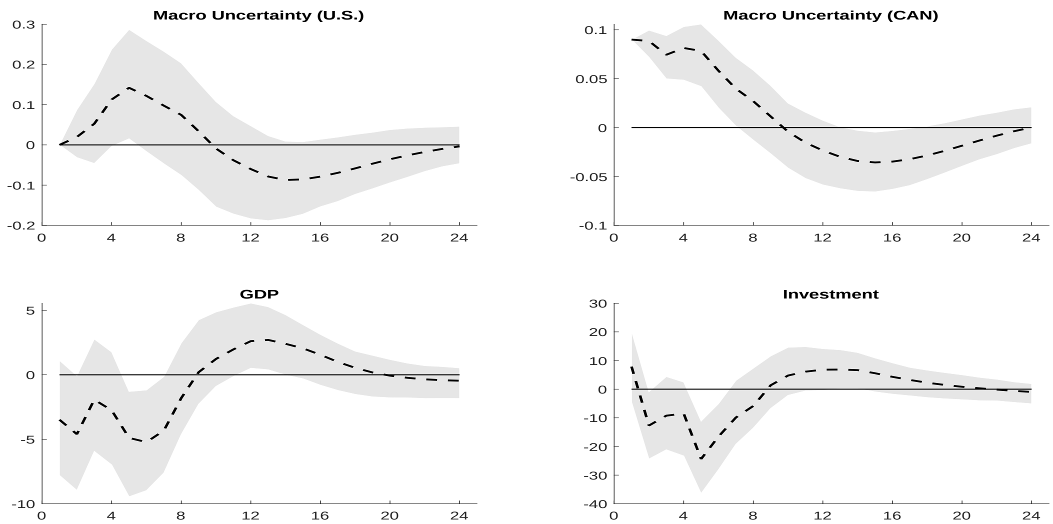
# A Data

Table 2: Data description

| Series | Description | Source | Vector | Transformation |
|---|---|---|---|---|
| Macro Uncertainty US | `www.sydneyludvigson.com/macro-and-financial-uncertainty-indexes` | | | level |
| GDP | Real Gross domestic product , chained (2012) dollars | statcan | v62305752 | log-difference |
| Investment | Real Gross fixed capital formation, chained (2012) dollars | statcan | v62305732 | log-difference |
| Inflation | Implicit price index : Gross domestic product, 2012 = 100 | statcan | v62307282 | log-difference |
| 10-year Governmental bonds | Governmental bonds (average rate) (10+ years) | statcan | v122487 | level |
| Treasury bills (3 months) | Treasury bills (3 months) | statcan | v122541 | level |
| Term Spread | Government Bonds (10+ years) - Treasury Bond (3 months) | v122487-v122541 | | level |
| Prices | Implicit price index : Gross domestic product, 2012 = 100 | statcan | v62307282 | level |
| Consumption | Real Final consumption expenditure, chained (2012) dollars | statcan | v62305723 | log-difference |
| Durable Consumption | Real Final consumption expenditure, Durable goods, chained (2012) $ | statcan | v62305726 | log-difference |
| Employment | Employment total | statcan | v24793 | log-difference |
| Unemployment rate | Unemployment rate | statcan | v2062815 | log-difference |

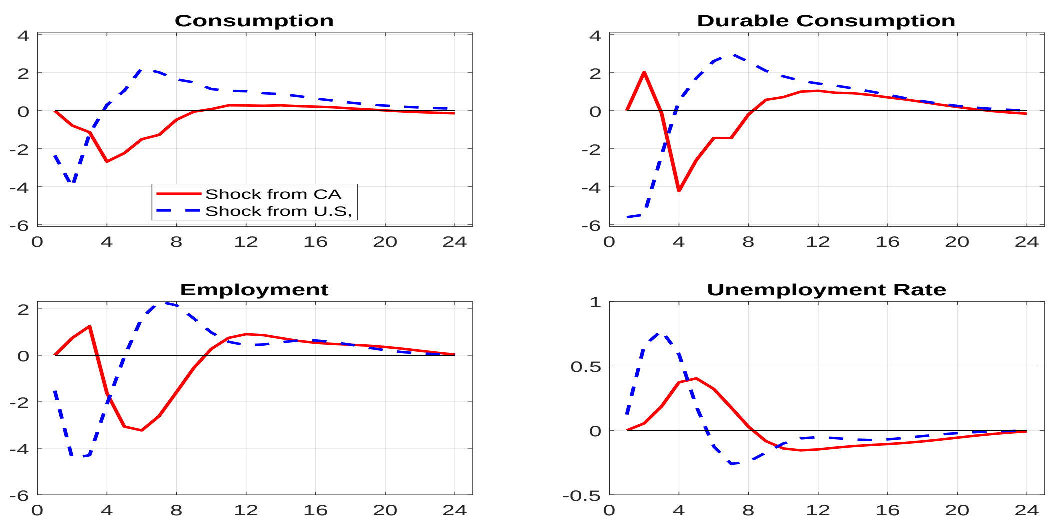
# B Robustness Analysis

Figure 10: **Macroeconomic Impacts of a Shock to Canadian Uncertainty: Alternative Ordering**



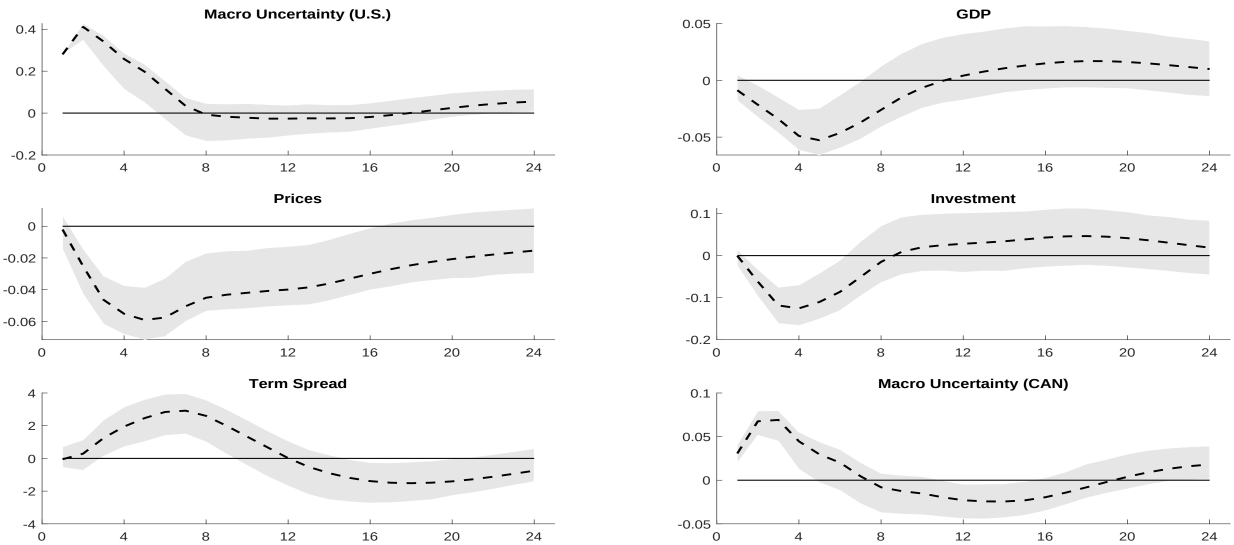

*NOTES: This figure shows IRFs from a VAR where our Canadian uncertainty measured is ordered second.*

Figure 11: **Impacts of Uncertainty Shocks on Consumption and Labor Market**



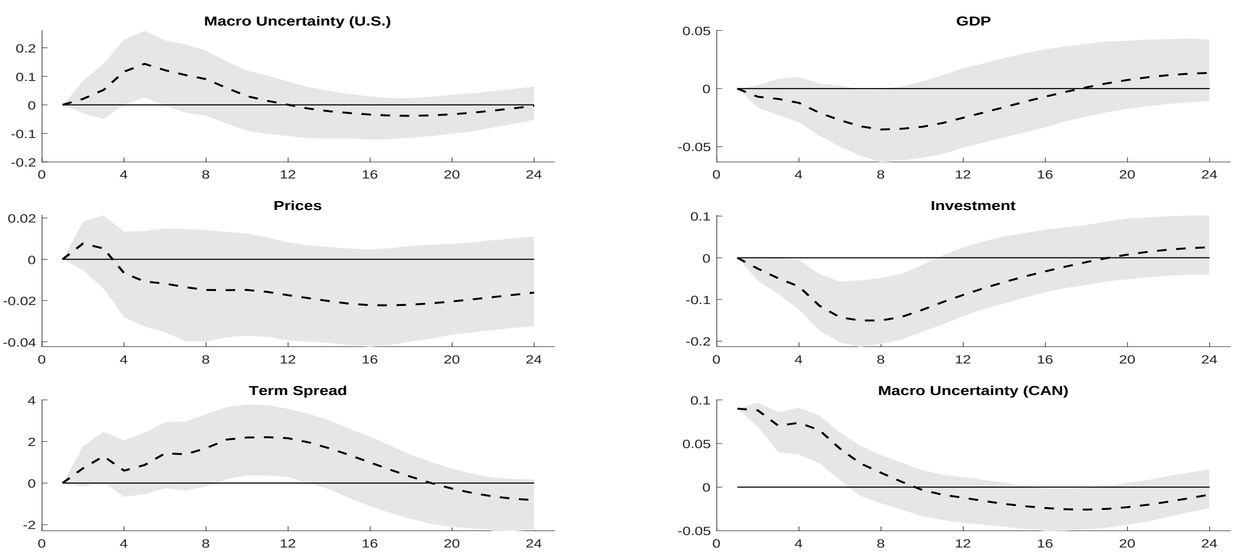

*NOTES: This figure compares the IRFs point estimates for consumption and labour market variables.*

Figure 12: **Macroeconomic Impacts of a Shock to US Uncertainty: VAR in Levels**




*NOTES: This figure shows IRFs to the US uncertainty shock from the VAR containing log-level variables rather than growth rates. A linear trend is also included.*

Figure 13: **Macroeconomic Impacts of a Shock to Canadian Uncertainty: VAR in Levels**




*NOTES: This figure shows IRFs to the Canadian uncertainty shock from the VAR containing log-level variables rather than growth rates. A linear trend is also included.*