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RISK SCENARIOS AND MACROECONOMIC IMPACTS: INSIGHTS FOR CANADIAN POLICY

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CS
2024s-03
WORKING PAPER

ISSN 2292-0838 (online version)

Risk Scenarios and Macroeconomic Impacts: Insights for Canadian Policy[*]

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Abstract/Résumé

This paper analyzes the macroeconomic implications of various risk scenarios for the Canadian economy, employing a Vector Autoregressive (VAR) model. We focus on three such scenarios: an aggressive monetary policy easing, an unexpected rise in oil prices and a sudden slowdown in U.S. economic activity. By illustrating how these scenarios would lead the economy to deviate from baseline macroeconomic forecasts, we demonstrate the value, for policy makers, of assessing the potential outcomes of key shocks through this type of analysis. We highlight the varied impacts of these shocks, such as the sensitivity of industrial production and housing markets to monetary easing, the demand-driven gains from rising oil prices, and the contractionary effects of a U.S. recession. Structural decomposition reveals how specific shocks shape economic outcomes, providing insights into their transmission mechanisms. These findings emphasize the importance of incorporating conditional forecasts into policy discussions to better understand potential risks facing the Canadian economy.

Cet article analyse les implications macroéconomiques de divers scénarios de risque pour l'économie canadienne, en utilisant un modèle vectoriel autorégressif (VAR). Nous nous concentrons sur trois de ces scénarios : un assouplissement agressif de la politique monétaire, une hausse inattendue des prix du pétrole et un ralentissement soudain de l'activité économique aux États-Unis. En illustrant comment ces scénarios conduiraient l'économie à s'écarter des prévisions macroéconomiques de base, nous démontrons l'intérêt, pour les décideurs politiques, d'évaluer les résultats potentiels de bouleversements majeurs par le biais de ce type d'analyse. Nous mettons en évidence les impacts variés de ces bouleversements, tels que la sensibilité de la production industrielle et des marchés du logement à l'assouplissement monétaire, les gains liés à la demande résultant de l'augmentation des prix du pétrole et les effets de contraction d'une récession aux États-Unis. La décomposition structurelle révèle comment des bouleversements spécifiques façonnent les résultats économiques, ce qui permet de mieux comprendre leurs mécanismes de transmission. Ces résultats soulignent l'importance d'incorporer des prévisions conditionnelles dans les discussions politiques afin de mieux comprendre les risques potentiels auxquels l'économie canadienne est confrontée.

[*] The financial support of CIRANO is gratefully acknowledged. Any errors and omissions are our own.

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Keywords/Mots-clés: Economic forecasts, risk scenarios, VAR, macroeconomic fluctuations, conditional forecasts / Prévisions économiques, scénarios de risque, VAR, fluctuations macroéconomiques, prévisions conditionnelles

JEL Codes : E32, F41, F44

Pour citer ce document / To quote this document
Moran, K., Stevanovic, D., & Surprenant, S. (2024). Risk Scenarios and Macroeconomic Impacts: Insights for Canadian Policy (2024s-03, Working Papers, CIRANO.)
https://doi.org/10.54932/DCXI8467

1 Introduction

Forecasts are integral to policy discussions at central banks and government agencies, serving as a foundation for such deliberations. These discussions typically begin with a baseline, or *unconditional*, scenario. The baseline forecast represents the most likely outcome based on the information available at the time of prediction, under the assumption that no unforeseen events will occur in the future.[1]

However, the future evolution of the economy may deviate from the central trend identified in the baseline forecast, making it essential to evaluate the associated risks. In this context, public policy has a natural interest in *risk scenarios* that examine the sensitivity of forecasts to specific eventualities which, while not the most probable, remain plausible. These "what-if" scenarios may include assessing how forecasts change under an alternative policy trajectory, incorporating additional external information into the forecast, or conducting stress tests to evaluate the banking sector's vulnerability to an economic downturn (McCracken and McGillicuddy, 2019; Antolin-Diaz et al., 2021).[2]

Risk scenarios are featured in various reports and budgetary outlooks recently published by Canadian officials, underscoring their significance.[3] Furthermore, the growing importance of risk scenarios was recently emphasized in the Bernanke (2024) report on the Bank of England, which advocates for their expanded role in the institution's forecasting and communication strategies. Indeed, conditional forecasts help policymakers to consider a range of possible outcomes based on different risk scenarios, which is essential for navigating in uncertain environments. Our objective is to foster dialogue on improving the development and use of conditional forecasts, recognizing their pivotal role in creating effective and responsive public policy.

[1]Formal statistical models align the baseline forecast with the model's expected future values of the variables of interest. This approach is motivated by the desirable statistical properties of expectations, particularly when the objective is to minimize the mean squared error of the forecasts.

[2]The terms "risk scenarios," "forecast scenarios," and "conditional forecasts" are used interchangeably in the literature. This paper adopts the first two terms as synonyms. Note that the concept of risk scenario differs from density forecasting or quantile regressions, which focus on assessing forecast uncertainty or predicting rare events but without the narrative content of risk scenarios.

[3]Examples of reports using risk scenarios include: CMHC's 2024 Housing Market Outlook, the 2024 Fall Statement of the Ontario Finance Minister, and the 2024 Fall Statement of the Quebec Finance Minister.

This paper argues that risk scenarios for analyzing the Canadian economy should be developed and implemented in a coherent, systematic, and transparent manner. This is crucial because the methodologies used to construct such scenarios are often neither standardized nor clearly communicated, which undermines their effectiveness as narrative tools. Additionally, employing a formal statistical framework emphasizes the connections between shocks, their transmission through the economy and the resulting scenarios.

We demonstrate the application of such a formal framework using Vector Autoregressive (VAR) models, a widely used statistical tool for generating forecasts. Two notable academic contributions have explored approaches for modifying forecasts to align them with risk scenarios (Waggoner and Zha, 1999; Baumeister and Kilian, 2014). Several empirical studies highlight the utility of these methods by generating scenario-compatible forecasts (Jarociński, 2010; Giannone et al., 2014; Bańbura et al., 2015; McCracken and McGillicuddy, 2019). Despite this active body of literature, academic research specifically addressing the Canadian economy remains notably scarce.

Our VAR model includes six Canadian macroeconomic aggregates: the Canada-US exchange rate, inflation, housing starts and prices, industrial production and a short-term interest rate reflecting monetary policy. Given the significance influence of energy and the US economy on Canada's economic activity, the VAR also incorporates measures of oil prices and US economic activity. We evaluate three scenarios with potential impacts on the Canadian economy. Domestically, we examine a scenario involving a faster-than-expected loosening of monetary policy. Internationally, we assess two scenarios: an unforeseen increase in oil prices and a surprise downturn in US economic activity.

The monetary policy scenario highlights the nuanced effects of monetary policy transmission in Canada. On the one hand, inflation remains surprisingly muted following the aggressive rate cuts featured in the scenario, reflecting the limited influence of monetary policy shocks on short-term price variability. On the other, industrial production increases, demonstrating a delayed but meaningful response. The housing market reacts more quickly, with sharp increases in prices followed by a gradual rise in housing starts, showcasing the sector's sensitivity to monetary easing. Additionally, the Canadian dollar appreciates due to strengthened capital flows and improved liquidity. These findings underscore the varied transmission mechanisms of monetary policy across sectors and time.

The analysis of the two international scenarios demonstrates the significant influence of external factors on the Canadian economy. A sustained rise in oil prices acts as a positive demand shock, boosting industrial production, housing prices, and the exchange rate. Conversely, a U.S. recession has severe adverse effects, leading to contractions in industrial production and housing markets, as well as a sharp depreciation of the Canadian dollar. The Bank of Canada's policy response, involving swift interest rate cuts, mitigates some of the negative impacts but cannot fully offset the broader spillover effects. These scenarios underscore Canada's economic vulnerability to global shocks and highlight the importance of proactive and adaptive policy measures.

The scenarios analyzed in this paper show how policy decisions and global events can influence the Canadian economy, causing deviations from baseline forecasts. Conditional forecasts and structural decompositions provide a framework for assessing risks by constructing quantitative narratives of potential future events. These examples highlight the value of risk scenarios, enabling decision-makers to evaluate the sensitivity of forecasts to plausible but less likely outcomes.

Unlike density forecasts, which are used to assess forecast uncertainty and predict rare events (Adrian et al., 2019; Lenza et al., 2023), risk scenarios allow policymakers to project the outcomes of variables of interest under hypothetical paths of risk factors and to evaluate their impact on the baseline scenario. The applications of conditional forecasts are diverse, encompassing academic research, stress-testing in the banking sector, and the management of monetary policy (McCracken and McGillicuddy, 2019).

The remainder of the paper is organized as follows. Section 2 introduces the notation and methodologies. Section 3 discusses our contribution, defines the VAR model and presents the data used for estimation. Section 4 presents the scenarios and provides a discussion of the results. Section 5 concludes and suggests avenues for future research.

2 Forecast Scenarios: Methodology

This section shows how to construct risk or forecast scenarios, beginning with a simple two-variable example —one variable representing economic activity and the other monetary policy— to build intuition. We then extend the discussion to the general case. Throughout, we highlight the connection between these scenarios and the implicit assumptions about the underlying shocks.

2.1 A two-variable model

Consider a simple model that links y_t, representing variables associated with economic activity, and x_t, a policy variable serving as a proxy for monetary policy decisions:

$$\begin{bmatrix} y_{t+1} \\ x_{t+1} \end{bmatrix} = \begin{bmatrix} a_1 & a_2 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} + \begin{bmatrix} u^y_{t+1} \\ u^x_{t+1} \end{bmatrix} \tag{1}$$

where u^y_{t+1} and u^x_{t+1} are reduced-form innovations, ie. white-noise processes representing the linearly unpredictable components in the evolution of y_{t+1} and x_{t+1}. Model (1), adapted from Walsh (2017), is deliberately simplified to emphasize intuition. By iterating on the first row of (1), we can see how the future values of $y_{t+h}, h = 1, 2, \cdots$ depend on predetermined factors known at time t as well as on future values for the innovations. Reporting only the first three future values, this becomes:

$$\begin{bmatrix} y_{t+1} \\ y_{t+2} \\ y_{t+3} \end{bmatrix} = \underbrace{\begin{bmatrix} a_1 & a_2 \\ a_1^2 & a_1 a_2 \\ a_1^3 & a_1^2 a_2 \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix}}_{\text{predetermined}} + \underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_1 & a_2 & 1 & 0 & 0 & 0 \\ a_1^2 & a_1 a_2 & a_1 & a_2 & 1 & 0 \end{bmatrix} \begin{bmatrix} u^y_{t+1} \\ u^x_{t+1} \\ u^y_{t+2} \\ u^x_{t+2} \\ u^y_{t+3} \\ u^x_{t+3} \end{bmatrix}}_{\text{future values of innovations}} \tag{2}$$

A *baseline forecast* is derived by setting future innovations to zero and considering only the predetermined part of (2) only. For illustrative purposes, assume $y_t = x_t = 0$. Under that assumption, it is clear that any deviation from the baseline must result from unexpected realizations of the innovations:

$$\begin{bmatrix} y_{t+1} \\ y_{t+2} \\ y_{t+3} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_1 & a_2 & 1 & 0 & 0 & 0 \\ a_1^2 & a_1 a_2 & a_1 & a_2 & 1 & 0 \end{bmatrix} \begin{bmatrix} u^y_{t+1} \\ u^x_{t+1} \\ u^y_{t+2} \\ u^x_{t+2} \\ u^y_{t+3} \\ u^x_{t+3} \end{bmatrix} \tag{3}$$

Similar logic applies to the second line of (1) but the model's simple structure implies

$$\begin{bmatrix} x_{t+1} \\ x_{t+2} \\ x_{t+3} \end{bmatrix} = \begin{bmatrix} u^x_{t+1} \\ u^x_{t+2} \\ u^x_{t+3} \end{bmatrix} \tag{4}$$

Forecast scenarios can now be constructed using (3)-(4). following Waggoner and Zha (1999), involves three steps: (1) specifying a particular scenario for the future values of a subset of variables, (2) deriving the innovations consistent with that scenario, and (3) computing how the forecasts for the remaining variables are affected.[4] For instance, one scenario could impose future values of the policy variable x_{t+1}, x_{t+2} and x_{t+3} to reflect a monetary policy tightening. Equation (4) would then determine the values of u^x_{t+1}, u^x_{t+2} and u^x_{t+3} required to achieve this tightening, while (3) would be used to assess how the baseline forecast for the non-policy variables changes as a result.[5]

[4] The formulas involved in producing these types of scenarios were initially introduced by Doan et al. (1984). The key contribution of Waggoner and Zha (1999) was to develop a method for conducting proper Bayesian inference about these constrained forecasts. In this paper, we refer to the approach as Waggoner and Zha (1999) for its focus on forecast scenarios, even though we apply frequentist methods.

[5] In this simple example, the scenario imposed on x_{t+1}, x_{t+2} and x_{t+3} uniquely determines u^x_{t+1}, u^x_{t+2} and u^x_{t+3}. This uniqueness does not necessarily hold in the general case discussed below.

One important shortcoming of the Waggoner and Zha (1999) method is that using reduced-form innovations to generate specific paths for the variables in the forecast scenario leaves the origin of these innovations ambiguous. For example, in a monetary loosening scenario, the decreases in the monetary policy variable could result from a response to unforeseen economic developments or, alternatively, from a deliberate policy decision to relax monetary conditions. To address this issue, Baumeister and Kilian (2014) propose constructing forecast scenarios based on the structural version of the model. In the context of (1), this approach involves specifying that fluctuations in the two variables model arise from policy and non-policy shocks ϵ^x_{t+1} and ϵ^y_{t+1}, which are related to the reduced-form innovations by

$$\begin{bmatrix} u^y_{t+1} \\ u^x_{t+1} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \phi & 1 \end{bmatrix} \begin{bmatrix} \epsilon^y_{t+1} \\ \epsilon^x_{t+1} \end{bmatrix} \tag{5}$$

where again the structure is simplified to focus on intuition. Now, (5) shows that innovations to the policy variable (u^x_{t+1}) reflect the reaction of monetary authorities to real developments (ϵ^y_{t+1}) and actual instances of policy shocks (ϵ^x_{t+1}). Entering (5) in (3)-(4) leads to

$$\begin{bmatrix} y_{t+1} \\ y_{t+2} \\ y_{t+3} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_1 + a_2\phi & a_2 & 1 & 0 & 0 & 0 \\ a_1^2 + \phi a_1 a_2 & a_1 + a_2\phi & 1 & a_2 & 1 & 0 \end{bmatrix} \begin{bmatrix} \epsilon^y_{t+1} \\ \epsilon^x_{t+1} \\ \epsilon^y_{t+2} \\ \epsilon^x_{t+2} \\ \epsilon^y_{t+3} \\ \epsilon^x_{t+3} \end{bmatrix} \tag{6}$$

and

$$
\begin{bmatrix} x_{t+1} \\ x_{t+2} \\ x_{t+3} \end{bmatrix} = \begin{bmatrix} \phi & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & \phi & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \phi & 1 \end{bmatrix} \begin{bmatrix} \epsilon^y_{t+1} \\ \epsilon^x_{t+1} \\ \epsilon^y_{t+2} \\ \epsilon^x_{t+2} \\ \epsilon^y_{t+3} \\ \epsilon^x_{t+3} \end{bmatrix} \tag{7}
$$

A forecast scenario using Baumeister and Kilian (2014) then involves specifying sequences of values for the monetary policy shocks ϵ^x_{t+1}, ϵ^x_{t+2} and ϵ^x_{t+3} (such as deliberate instances of monetary loosening) and then, using (6)-(7), computing how the forecasts for both variables are changed.

2.2 The general case

A general formulation begins with the following standard VAR model with p lags and k variables arranged in the $k \cdot 1$ vector $\mathbf{y_t}$:

$$
\mathbf{y_t} = \nu + \sum_{j=1}^{p} \mathbf{A_j y_{t-j}} + \mathbf{u_t}, \tag{8}
$$

where the vector of innovations $\mathbf{u_t}$ follows a weak white noise process, ie. $\mathbb{E}(\mathbf{u_t}) = \mathbf{0}$ and $\mathbb{E}(\mathbf{u_t u_s}') = \mathbf{\Sigma_u}$ for $t = s$ and $\mathbf{0}$ otherwise.[6]

It is convenient to rewrite (8) as a VAR(1) process by stacking $p-1$ lags of $\mathbf{y_t}$ vertically to obtain:

$$
\mathbf{Y_t} = \mu + \mathbf{A Y_{t-1}} + \mathbf{U_t}, \tag{9}
$$

[6]The presentation here follows Kilian and Lütkepohl (2017) as well as part of the argument in Jarociński (2010).

where $\mathbf{Y_t} = (\mathbf{y_t}', \ldots, \mathbf{y_{t-p+1}}')'$, $\mu = (\nu', \mathbf{0}', \ldots, \mathbf{0}')'$, $\mathbf{U_t} = (\mathbf{u_t}', \mathbf{0}', \ldots, \mathbf{0})'$ and

$$\mathbf{A} = \begin{bmatrix} \mathbf{A_1} & \ldots & \mathbf{A_{p-1}} & \mathbf{A_p} \\ \mathbf{I_k} & \ldots & \mathbf{0_k} & \mathbf{0_k} \\ \vdots & \ddots & \vdots & \vdots \\ \mathbf{0_k} & \ldots & \mathbf{I_k} & \mathbf{0_k} \end{bmatrix}.$$

Next, iterate equation (9) forward to obtain an expression for all future values of $\mathbf{Y_t}$:

$$\mathbf{Y_{t+h}} = \left(\sum_{j=0}^{h-1} \mathbf{A}^j\right) \mu + \mathbf{A}^h \mathbf{Y_t} + \sum_{j=0}^{h-1} \mathbf{A}^j \mathbf{U_{t+h-j}},$$

from which an expression for the futue values of the original vector $\mathbf{y_t}$ can be obtained with the help of the $K \times Kp$ selection matrix $\mathbf{J} := \left[\mathbf{I_k}, \mathbf{0_{k\times k(p-1)}}\right]$ such that $\mathbf{y_t} = \mathbf{JY_t}$ and $\mathbf{u_t} = \mathbf{JU_t}$:[7]

$$\begin{aligned} \mathbf{y_{t+h}} = \mathbf{JY_{t+h}} &= \mathbf{J}\left(\sum_{j=0}^{h-1} \mathbf{A}^j\right) \mu + \mathbf{JA}^h \mathbf{Y_t} + \sum_{j=0}^{h-1} \mathbf{JA}^j \mathbf{J}'\mathbf{JU_{t+h-j}} \\ \implies \mathbf{y_{t+h}} &= \mathbf{J}\left(\sum_{j=0}^{h-1} \mathbf{A}^j\right) \mu + \mathbf{JA}^h \mathbf{Y_t} + \sum_{j=0}^{h-1} \mathbf{JA}^j \mathbf{J}'\mathbf{u_{t+h-j}}. \end{aligned} \tag{10}$$

As in the simple model, (10) show that future values of $\mathbf{y_t}$ depend on both predetermined factors known at time t and the future values of the innovations. The unconditional expectation, $\mathbf{y_{t+h|t}} := \mathbb{E}\left(\mathbf{y_{t+h}} \middle| \{\mathbf{y_s}\}_{s=1}^{t}\right)$, is calculated by setting all future innovations to their expected values of zero. This simplification leaves only the first two terms of (10), allowing the expression to be rewritten as follows:

$$\mathbf{y_{t+h}} = \mathbf{y_{t+h|t}} + \sum_{j=0}^{h-1} \mathbf{JA}^j \mathbf{J}'\mathbf{u_{t+h-j}}, \tag{11}$$

[7] Note that $\mathbf{U_t} = \mathbf{J}'\mathbf{JU_t}$.

or

$$\mathbf{y_{t+h}} = \mathbf{y_{t+h|t}} + \sum_{j=0}^{h-1} \mathbf{\Phi}_j \mathbf{u_{t+h-j}}, \tag{12}$$

where $\mathbf{J}\mathbf{A}^j\mathbf{J}' := \mathbf{\Phi}_j$ and $\mathbf{y_{t+h|t}}$ defines the *baseline* scenario. As before (12) illustrates that future values of $\mathbf{y_{t+h}}$ will depart from that baseline only when innovations take on unexpected values.

Equation (12) can also be used to see how forecasts diverge from baseline because of unforseen structural shocks rather than the statistical innovations $\mathbf{u_t}$. To do so, we make the common assumption that $\mathbf{u_t}$ is a linear combination of underlying structural shocks, so that $\mathbf{u_t} = \mathbf{D}\epsilon_\mathbf{t}$ for a nonsingular matrix with $\mathbf{D}$, $\mathbb{E}(\epsilon_t) = 0$ and $\mathbb{E}\left(\epsilon_\mathbf{t}\epsilon_\mathbf{t}'\right) = \mathbf{I}_K$. In such a case, the last part of (12) is now

$$\mathbf{\Phi}_j \mathbf{u_{t+h-j}} = \mathbf{\Phi}_j \mathbf{D}\mathbf{D}^{-1}\mathbf{u_{t+h-j}} = \mathbf{\Phi}_j \mathbf{D}\epsilon_\mathbf{t+h-j} := \mathbf{\Theta_j}\epsilon_\mathbf{t+h-j}, \tag{13}$$

where the $\mathbf{\Theta_j}$ matrices underly the impulse response functions commonly analysed with VARs. Combining equations (12) and (13) can help us understand how future outcomes $(\mathbf{y_{t+1}}, \ldots, \mathbf{y_{t+h}})$ may come to differ from their forecasted values $(\mathbf{y_{t+1|t}}, \ldots, \mathbf{y_{t+h|t}})$ through the effects of future sequences of structural shocks $(\epsilon_\mathbf{t+1}, \ldots, \epsilon_\mathbf{t+h})$. In particular, we can isolate the effect of each individual shock through the following decomposition

$$\mathbf{y_{t+h}} - \mathbf{y_{t+h|t}} = \sum_{j=0}^{h-1} \mathbf{\Theta_j}\epsilon_\mathbf{t+h-j} = \sum_{k=1}^{K} \underbrace{\sum_{j=0}^{h-1} \mathbf{\Theta_{j,.,k}}\epsilon_{k,t+h-j}}_{\text{Contribution of shock } k} . \tag{14}$$

2.3 Constructing risk scenarios

It is transparent from (12) and (14) that constructing forecast scenarios always amounts to choosing sequences of future shocks. The two expressions also suggest that building these scenarios can either be done directly, by formulating scenarios in terms of structural shocks (Baumeister and Kilian, 2014), or indirectly, by formulating scenarios in terms of realized outcomes (Waggoner and Zha, 1999). In either case, the scenario relates to a notion of risk by exploring how future events may push realized values away from the baseline forecast. In this way, forecast scenarios aim to tell us why and by how much a point forecast could turn out to be wrong.

To apply the method proposed by Waggoner and Zha (1999), subtract the forecasts $\mathbf{y_{t+h|t}}$ from both sides of equation (12) and stack the resulting equations at horizons $h = 1, \ldots, H$ vertically to obtain

$$\begin{bmatrix} \mathbf{y_{t+1}} - \mathbf{y_{t+1|t}} \\ \mathbf{y_{t+2}} - \mathbf{y_{t+2|t}} \\ \vdots \\ \mathbf{y_{t+H}} - \mathbf{y_{t+H|t}} \end{bmatrix} = \begin{bmatrix} \mathbf{\Phi_0} & \mathbf{0_K} & \ldots & \mathbf{0_K} \\ \mathbf{\Phi_1} & \mathbf{\Phi_0} & \ldots & \mathbf{0_K} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{\Phi_{H-1}} & \mathbf{\Phi_{H-2}} & \ldots & \mathbf{\Phi_0} \end{bmatrix} \begin{bmatrix} \mathbf{u_{t+1}} \\ \mathbf{u_{t+2}} \\ \vdots \\ \mathbf{u_{t+H}} \end{bmatrix}$$

or, more concisely,

$$\underset{KH\times 1}{\mathbf{r}} = \underset{KH\times KH}{\mathbf{R}} \; \underset{KH\times 1}{\mathbf{u}}. \tag{15}$$

Note that each row in equation (15) corresponds to a deviation from baseline for a specific variable at a specific horizon. For concreteness, suppose that we are working at a monthly frequency with two variables ($K = 2$), that we are producing forecasts for up to one year ahead ($H = 12$) and that we want to analyse a scenario imposing values for the second variable's next six values ($y_{2,t+1}^{scenario}, \ldots, y_{2,t+6}^{scenario}$). This would single out rows 2, 4, 6, 8, 10 and 12 out of the 24 rows contained in (15) and this restricted form would then be written $\mathbf{r}_\kappa = \mathbf{R}_{\kappa,\cdot}\mathbf{u}_\kappa$, where the imposed restrictions on $y_{2,t+1}^{scenario}, \ldots, y_{2,t+6}^{scenario}$ have been used to construct $\mathbf{r}_\kappa$.

The astute reader will have noticed that $\mathbf{R}_{\kappa,\cdot}$ is not a square matrix and many sequences of innovations can therefore obey the restriction. Doan et al. (1984) proposed to privilege the minimal variance solution

$$\mathbf{u}^{scenario} = \underset{\mathbf{u}\in\mathbb{R}}{\operatorname{argmin}} \left\{\mathbf{u}'\mathbf{u}|\mathbf{R}_{\kappa,.}\mathbf{u}_{\kappa} = \mathbf{r}_{\kappa}\right\} = \mathbf{R}_{\kappa,.}{}' \left(\mathbf{R}_{\kappa,.}\mathbf{R}_{\kappa,.}{}'\right)^{-1} \mathbf{r}_{\kappa}$$

where the appeal is that it corresponds to the 'smallest' perturbation available that ensures the restrictions are met. As pointed out by Jarociński (2010) and Antolin-Diaz et al. (2021), this implicitly selects sequences of structural shocks since $\epsilon_{\mathbf{t+h}} = \mathbf{D}^{-1}\mathbf{u}_{\mathbf{t+h}}$. We exploit this observation along with the decomposition presented in equation (14) to visualize the dynamic contribution of each of the structural shock implied by our reduced-form scenarios.

In contrast, the approach proposed by Baumeister and Kilian (2014) involves formulating scenarios directly in terms of sequences of future structural shocks. Although one could implement this approach using equation (12) and the relationship between structural shocks and the noise vector, we can also proceed iteratively from equation (8) by simply simulating future values as

$$\mathbf{y}_{\mathbf{t+h|t}}{}^{scenario} = \nu + \sum_{j=1}^{p} \mathbf{A_j}\mathbf{y}_{\mathbf{t+h-j|t}}{}^{scenario} + \mathbf{D}\epsilon_{\mathbf{t+h-j|t}}{}^{scenario}$$

where $\mathbf{y}_{\mathbf{t|t}}{}^{scenario}, \ldots, \mathbf{y}_{\mathbf{t-p+1|t}}{}^{scenario}$ correspond to the last p observed values (i.e., $\mathbf{y}_{\mathbf{t}}, \ldots, \mathbf{y}_{\mathbf{t-p+1}}$). Note that if all future shocks are set to zero, the simulation described above recovers the unconditional expectations $\mathbf{y}_{\mathbf{t+h|t}}{}^{scenario} = \mathbf{y}_{\mathbf{t+h|t}}$ because $\mathbb{E}\left(\mathbf{D}\epsilon_{\mathbf{t+h-j|t}}\middle|\left\{\mathbf{y_s}\right\}_{s=1}^{t}\right) = \mathbf{0}$. More generally, if we stack the sequence of future structural shock vectors like the sequence of noise vectors as in equation (15) and select a subset of rows κ for which we impose nonzero values, we can see that this simulation recovers the following expectation

$$\mathbf{y}_{\mathbf{t+h|t}}{}^{scenario} = \mathbb{E}\left(\mathbf{y}_{\mathbf{t+h}}\middle|\left\{\mathbf{y_s}\right\}_{s=1}^{t}, \epsilon_{\kappa}{}^{scenario}\right)$$

since the expected value of the non-restricted structural shocks is zero.

2.4 Variance Decomposition

When the structural shocks influencing the evolution of a VAR model can be identified, it is useful to assess their relative importance for each variable through a forecast error variance decomposition. This decomposition quantifies, for each identified shock, variable and forecast horizon, the contribution of the shock to the variability of the variable.

This decomposition is conducted as follows. Using the notation of Kilian and Lütkepohl (2017), the forecast error in the vector of variables $\mathbf{y}$ at horizon h can be expressed in terms of structural shocks as $\mathbf{y}_{t+h} - \mathbb{E}(\mathbf{y}_{t+h}) = \sum_{j=0}^{h-1} \mathbf{\Theta}_j \epsilon_{t+h-j}$. Hence the following expression obtains for the mean squared forecast error:

$$MSPE(h) = \mathbb{E}\left(\left(\mathbf{y}_{t+h} - \mathbb{E}(\mathbf{y}_{t+h})\right) \left(\mathbf{y}_{t+h} - \mathbb{E}(\mathbf{y}_{t+h})\right)' \right) = \sum_{j=0}^{h-1} \mathbf{\Theta}_j \mathbf{\Theta}_j'.$$

Since the response of variable k to shock l at horizon h is given by $\theta_{k,j,h}$, the (k,l) element of $\mathbf{\Theta}_h$, the contribution of shock l to the variance of the forecast error of variable k at horizon h is given by

$$MSPE_{k,l}(h) = \theta_{k,l,0}^2 + \cdots + \theta_{k,l,h-1}^2.$$

The total variance (representing the aggregate variability of variable k sums over the contributions of all shocks:, that is, $MSPE_k(h) = \sum_{l=1}^{K} MSPE_{k,l}(h)$. Finally, the *relative* decomposition is obtained by normalizing these contributions by the total variance, dividing both sides by $MSPE_k(h)$.

3 Model Specification and Data

The VAR model in our analysis includes eight variables and is estimated using monthly data spanning January 1992 to June 2024. The starting date aligns with Champagne and Sekkel (2018), who note that the adoption of inflation targeting in 1991 altered the effects of monetary policy shocks on the Canadian economy. Our benchmark estimation uses $p = 2$ lags, as suggested by the Akaike criterion.

Our model incorporates a range of variables selected based on the scenarios under consideration and the identified shocks. The first two variables are the real price of oil (op_t) and the US industrial production (ip_t^{US}) index, both sourced from the FRED-MD database (McCracken and Ng, 2016).[8] The remaining variables are Canadian macroeconomic indicators drawn from the database developed by Fortin-Gagnon et al. (2022): the price level as measured by the consumer price index (p_t^{CAN}), the industrial production index (ip_t^{CAN}), housing starts (hs_t^{CAN}) and the housing price index (hp_t^{CAN}), the bank rate (R_t^{CAN}) and the Canada-US exchange rate ($usdcad_t$).[9] All variables enter our VAR in log levels, except for the bank rate which is included in levels. This approach has become common practice as a means of guarding against the need to take a stance on the system's cointegration properties. As shown by Sims et al. (1990), OLS parameter estimates remain consistent when the model is estimated in levels even in the presence of unit roots.

The approach Baumeister and Kilian (2014) approach requires the identification of structural shocks, which we achieve using recursive short-run restrictions. This methodology is consistent with established practices in several studies employing VAR models to examine the Canadian economy (Kim and Roubini, 2000; Bhuiyan and Lucas, 2007; Li et al., 2010; Boivin et al., 2010; Moran et al., 2023). In these studies, global or U.S. variables are typically prioritized at the beginning of the vector $\mathbf{y}_t$, followed by Canadian-specific variables. Variables that are particularly sensitive to external events—such as financial asset prices in Li et al. (2010) or the exchange rate, as in our study and Kim and Roubini (2000)—are positioned last. Specifically, we adopt the following ordering:

$$\mathbf{y}_t = \begin{bmatrix} op_t & ip_t^{US} & p_t^{CAN} & ip_t^{CAN} & hs_t^{CAN} & hp_t^{CAN} & R_t^{CAN} & usdcad_t. \end{bmatrix} \tag{16}$$

Applying the Cholesky decomposition to the residuals' covariance matrix identifies the oil

[8] The price of oil is measured using the WTI benchmark deflated by the US CPI, a widely used metric in the literature on oil prices (Baumeister and Kilian, 2016).

[9] We consider housing variables to be relevant because fluctuations in real estate markets are often considered as the defining characteristic of a business cycle (Leamer, 2007, 2015). In addition, the structure of the mortgage market in Canada implies that monetary policy has strong and rapid impacts on housing markets (Nsafoaha and Deryb, 2024). The exchange rate is expressed in Canadian dollars per US dollars so that a decline is an appreciation of the Canadian dollar.

price shock with the corresponding reduced-form residual. Our oil price shocks still reflect a composite of contemporaneous factors since ordering real oil prices first implies only that this shock can influence real oil prices within the month. The Bank rate, measuring the stance of monetary policy, is ordered next to last which reflects the assumption that the Bank of Canada can react to a wide range of macroeconomic events within the month. This positioning implies that the monetary policy shocks we identify are equivalent to those that would obtain if we imposed a block recursive structure as pointed out Christiano et al. (1999). Finally, we assume that financial markets, represented by the exchange rate, are also forward-looking and respond to all shocks within the same month. Consequently, we order the exchange rate last.

Table 1 in the Appendix presents the results of the variance decomposition exercise applied to our estimated VAR. As outlined in Section 2.4, this exercise quantifies the contribution of each shock identified through the recursive strategy to the variability of the variables under consideration. The first highlight of Table 1 is the importance of shocks to the world price of oil (first panel) in explaining the variability of several Canadian macroaggregates, including the CPI, housing starts, industrial production, and the exchange rate. Consequently, we can expect that a conditional forecast (or scenario) involving oil prices will produce substantial deviations between the baseline forecast and the scenario forecast.

The second panel of Table 1 shows that shocks to U.S. economic activity generally play a smaller role in Canadian macroeconomic fluctuations. However, Canadian industrial production is an exception, exhibiting high sensitivity to U.S. economic variability. Finally, the third panel reveals that monetary policy shocks have a modest impact on most variables. Nevertheless, these shocks account for a notable share of volatility in housing prices.[10]

[10]The finding that monetary policy shocks contribute modestly to overall variability is consistent with standard results in the VAR literature. This, however, does not imply that *systematic* monetary policy—referring to the regular responses of monetary authorities to macroeconomic conditions—is unimportant.

4 Forecast Scenarios

In this section, we analyze both domestic and international scenarios that may pose risk to the outlook for the Canadian economy going forward. Domestically, our scenario assumes the Bank of Canada adopts a more aggressive interest rate reduction strategy than the one inherent to the baseline forecast, which itself reflects a loosening cycle prompted by the normalization of inflation rates and slower economic growth toward the end of our sample period in June 2024. On the international front, we consider two scenarios: one simulating the effects of a sharp increase in the real world oil price and another assessing the impact of a recession in the United States.

4.1 Monetary Policy

Our monetary policy scenario assumes that the Bank of Canada's ongoing loosening cycle unfolds more aggressively than anticipated in the baseline forecast. Specifically, we hypothesize that the Bank of Canada reduces interest rates by 50 basis points at every fixed announcement date until a floor of 2% is reached.[11] These reductions are then sustained for the remainder of the forecast period.

Figure 1 illustrates how implementing this scenario using the Waggoner and Zha (1999) method alters the projected path for the interest rate and the forecasts for the other Canadian variables. First, the inflation forecast shows only minor adjustments, consistent with the variance decomposition results (Table 1 in the Appendix), which indicate that monetary policy shocks contribute modestly to inflation variability, particularly at shorter horizons. Next, industrial production initially declines by approximately 0.5% below the baseline but recovers by the second year, eventually surpassing the baseline by 1.2%. This pattern reflects the delayed impact of lower borrowing costs and improved liquidity in stimulating economic growth.

Housing prices, on the other hand, respond rapidly, increasing by nearly 3.5% within

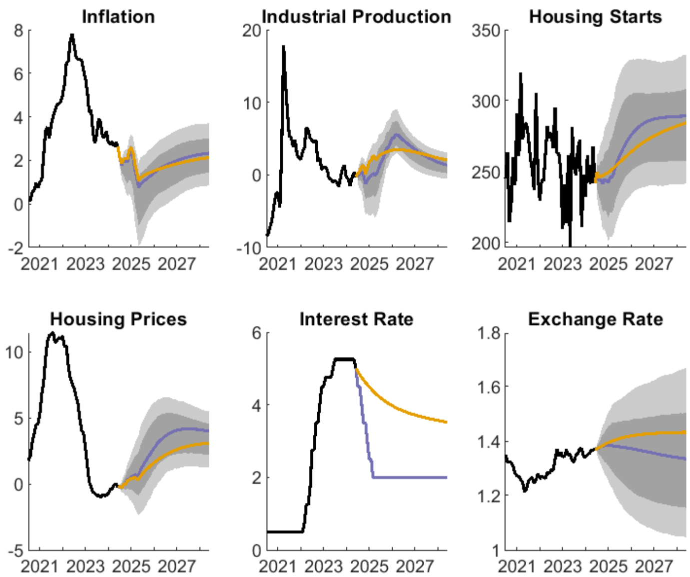
[11] The current calendar schedules decisions in the following eight months of 2025: January, March, April, June, July, September, October and December.

the first year relative to the baseline, while housing starts rise by 2.8% after a brief lag. This dynamic aligns with the view that housing demand reacts faster than housing supply to monetary policy shocks, as buyers capitalize on lower mortgage rates before developers adjust construction activity. Finally, the exchange rate appreciates by approximately 1.5%, reflecting strengthened capital flows and improved liquidity conditions.

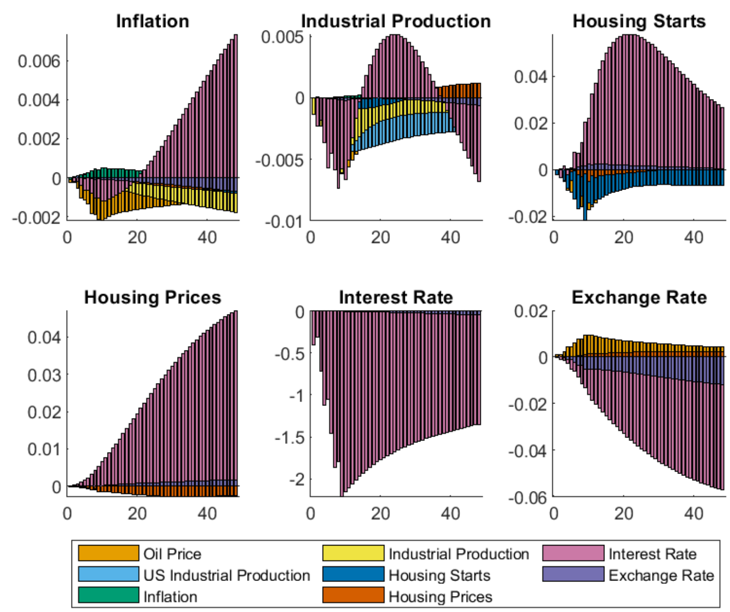
Recall from Section 2.3 that the Waggoner and Zha (1999) method selects sequences of the innovation vector $\mathbf{u}$ to generate the path prescribed by the scenario (in this case, aggressive monetary loosening) and computes how imposing these values modifies forecasts for all other variables. It is instructive to use the decomposition in (14) to identify which types of shocks the method relied on to produce these forecast changes. To this end, part (b) of Figure 1 decomposes, for each variable, the gap between the baseline and scenario forecasts according to the structural shocks responsible for that gap.

The figure confirms that this scenario is predominantly driven by monetary policy shocks. This dominance is evident not only in the decomposition of the interest rate but also in the responses of housing starts, inflation, housing prices, and the exchange rate, where the deviations between the baseline and scenario forecasts are almost entirely attributable to monetary policy shocks. However, certain nuances—such as a temporary price puzzle observed in the inflation response—suggest that other factors may moderate the overall effect of monetary policy changes. These findings align with the empirical literature on the transmission of monetary policy in Canada, such as Fortin-Gagnon et al. (2022), which highlights its differential impacts across economic sectors.

Figure 2 presents the results of an equivalent scenario implemented using the method of Baumeister and Kilian (2014). This approach involves specifying that the aggressive monetary policy loosening is generated by large negative monetary policy shocks over the 24-month period from February 2020 to February 2024. This scenario results in sharp declines in the interest rate, with both inflation and industrial production eventually exceeding their respective baseline forecasts. The housing market responds in a manner similar to the previous scenario.



(a) Forecasts



(b) Decomposition of Forecasts According to Structural Shocks

Figure 1: Monetary Policy Loosening Scenario with Waggoner and Zha (1999)

Note: Panel (a): Benchmark forecasts are in yellow and those under the scenario in purple. Shaded areas correspond to 68% and 90% moving block bootstrap confidence intervals. The real oil price, interest rate and exchange rate are reported in levels and other variables are shown in year-over-year growth rates. Panel (b): Decomposition of the forecasts according to implied structural shocks from equation (14)

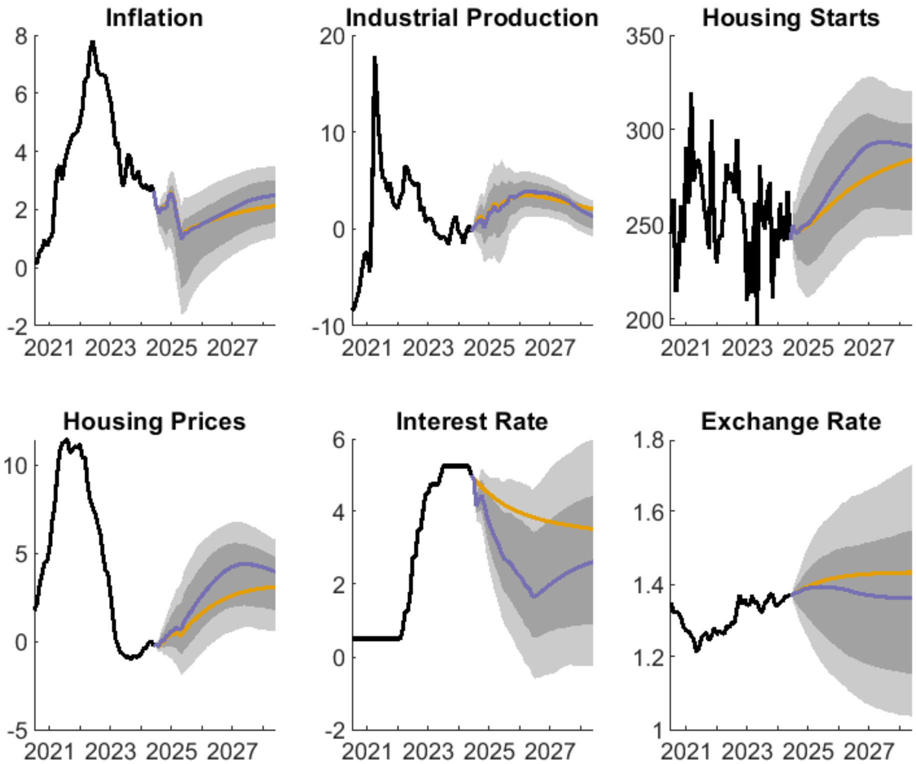


Figure 2: Monetary Policy Loosening Scenario with Baumeister and Kilian (2014)

Note: Benchmark forecasts are in yellow and those under the scenario in purple. Shaded areas correspond to 68% and 90% moving block bootstrap confidence intervals. The real oil price, interest rate and exchange rate are reported in levels and other variables are shown in year-over-year growth rates.

As the interest rate stabilizes towards the end of this 24-month period, housing prices begin to decline, and housing starts stabilize, possibly reflecting a supply-side adjustment as housing supply catches up with demand. These results are broadly consistent with the reduced-form monetary policy scenario depicted in Figure 1. The resemblance can be explained by the variance decomposition in Table 1, which highlights the dominance of monetary policy shocks in driving variations in interest rates. Under such conditions, scenarios that constrain the observed path of the interest rate are largely shaped by monetary policy shocks, leading to similar outcomes in reduced-form and structural scenario analyses.[12]

[12] Recall that a scenario computed using the Baumeister and Kilian (2014) method, which works with

4.2 Oil Price Scenario

Our first international scenario examines the impact of a sharp, unexpected increase in the real world price of oil. To model this, we simulate an 18-month rise in oil prices starting at the end of our sample period in June 2024. This increase is generated by applying 75% of the growth rates observed between January 2007 and June 2008—an important recent period characterized by sustained and rapid oil price escalation. For the remainder of the forecasting horizon, we generate unconditional forecasts. The results are presented in Figure 3. As above, the first panel of the figure compares the baseline versus scenario forecasts whereas the bottom panel examines how the Waggoner and Zha (1999) method created the scenarios.

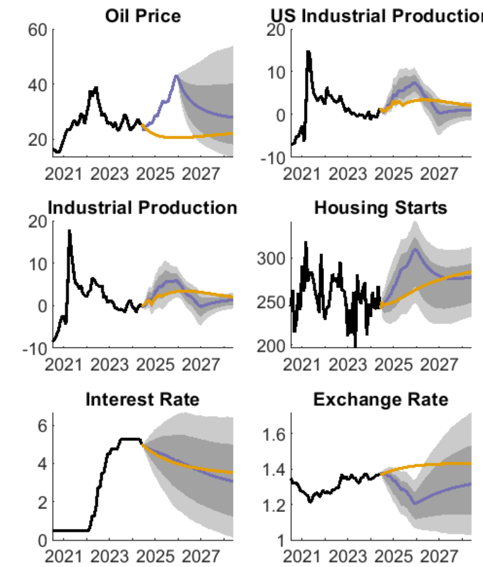
The figure shows that the sharp increases in the real oil price leads to higher industrial production relative to baseline for both Canada (+2.7%) and the US (+1.9%) while inflation rises by 0.8 percentage points above baseline, indicating a strong positive demand stimulus. The housing market also responds significantly, with housing prices increasing by 4.3% and housing starts by 3.6% over the forecast period. Additionally, the exchange rate appreciates by 2.2%, reflecting improved terms of trade and heightened demand for Canadian exports.

The structural decompositions presented in the bottom panel of the figure indicate that oil price shocks explain 30% of the variance in industrial production and 12% in housing starts. These movements are accompanied by inflation exceeding benchmark forecasts, suggesting that the scenario may be interpreted a reflecting a positive demand stimulus that boosts aggregate revenues in Canada. Responses in the housing market align with this interpretation, with both housing starts and prices increase more rapidly than they otherwise would.[13]

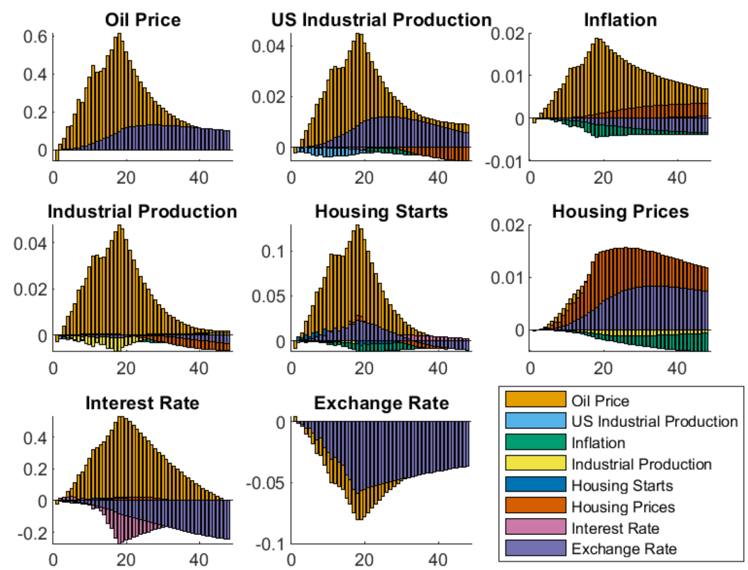
Building on these findings, Figure 4 refines the analysis by isolating the effects of

structural shocks instead of innovations, implies that Figure 2 does not need a bottom panel.

[13]The positive boost to aggregate revenue stemming from this oil price shock thus leads to more pronounced impacts on the housing market than the monetary shocks studied in the first scenario, which had the more limited effect of decreasing borrowing cost.



(a) Forecasts



(b) Decomposition of Forecasts According to Structural Shocks

Figure 3: Rapid Oil Price Increase Scenario with Waggoner and Zha (1999)

Note: Panel (a): Benchmark forecasts are in yellow and those under the scenario in purple. Shaded areas correspond to 68% and 90% moving block bootstrap confidence intervals. The real oil price, interest rate and exchange rate are reported in levels and other variables are shown in year-over-year growth rates. Panel (b): Decomposition of the forecasts according to implied structural shocks from equation (14).

oil price shocks using the Baumeister and Kilian (2014) methodology. To construct this scenario, we extracted the implied structural real oil price shock from the previous scenario and set all other shocks to zero. The results confirm our previous conclusions, showing that real oil price shocks act as positive demand shocks for the Canadian economy. Industrial production rises, housing prices increase sharply before stabilizing, and housing starts adjust more gradually as supply catches up to demand.

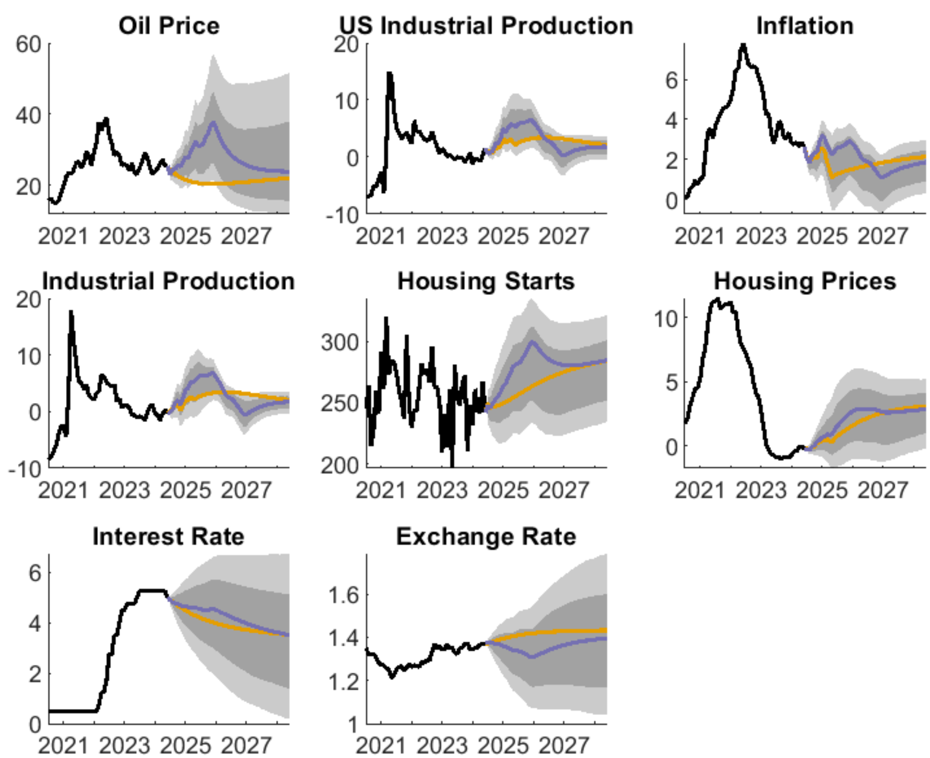


Figure 4: Rapid Oil Price Increase Scenario with Baumeister and Kilian (2014)

Note: Benchmark forecasts are in yellow and those under the scenario in purple. Shaded areas correspond to 68% and 90% moving block bootstrap confidence intervals. The real oil price, interest rate and exchange rate are reported in levels and other variables are shown in year-over-year growth rates.

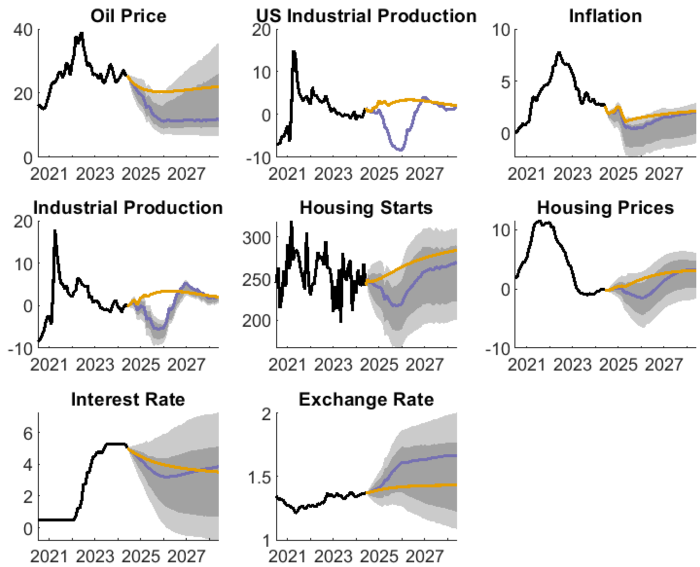
4.3 US Activity Scenario

The second international scenario examines the impact of a significant slowdown in the United States in the months following the end of our sample. To simulate this, we model a milder version of the Great Recession and its aftermath by setting the growth rate of U.S. industrial production to half the observed growth rates over the 48-month period beginning in December 2007. This period encompasses the Great Recession and its subsequent slow recovery, thereby capturing a recessionary event followed by gradual improvement.

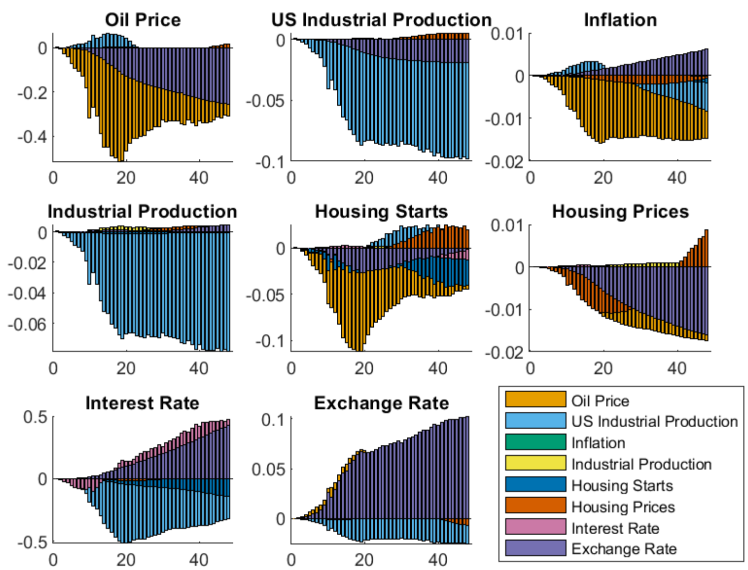
The results, compared to the benchmark forecasts, are presented in Figure 5. Given the strong trade and financial linkages between the two countries, it is expected that such a downturn in the U.S. economy would generate significant headwinds for Canada. Indeed, the figure shows that Canadian industrial production declines sharply, falling by 3.4% below the baseline at its trough. Housing starts and prices also experience significant contractions, decreasing by 4.2% and 3.5%, respectively. Inflation turns negative, with deflationary pressures pushing price levels 0.6 percentage points below the baseline. The Bank of Canada responds by aggressively cutting interest rates, with reductions exceeding the baseline by 75 basis points within the first year. Finally, the exchange rate depreciates by 2.8%, reflecting weaker export revenues and increased global risk aversion. Structural decompositions at the bottom of the figure indicate that 40% of the observed variability in industrial production is attributable to negative oil price shocks, which amplify the recessionary effects in Canada.

These developments align with the characterization of the U.S. recession scenario as a series of negative demand shocks. However, the decomposition in panel (b) of the figure reveals that much of the observed impact on inflation, housing starts and oil prices stems from negative oil price shocks. These shocks, as shown earlier, act as aggregate demand shocks for Canada. Interestingly, while oil price shocks drive declines in both housing starts and prices; the impact on housing starts appears more pronounced, as observed in the oil price scenario.

Figure 6 isolates the effects of the U.S. shock by constructing a Baumeister and Kilian (2014) scenario that utilizes only the U.S. shocks implied by the reduced-form Waggoner and Zha (1999) scenario presented in Figure 5. All other shocks are set to zero. The results reveal that the effects on oil prices and the housing market are considerably muted, showing only slight deviations from the benchmark forecasts. However, a notable finding is how closely Canadian industrial production mirrors its U.S. counterpart in both the structural and reduced-form scenarios. This alignment reflects the strong trade and supply chain linkages between the two economies, which facilitate the rapid transmission of U.S. economic downturns to Canada, particularly in sectors heavily reliant on cross-border trade. These results underscore the Canadian economy's vulnerability to external shocks and the importance of adaptive monetary policy in mitigating their adverse effects.



(a) Forecasts



(b) Decomposition of Forecasts According to Structural Shocks

Figure 5: US Economy Slowdown Scenario with Waggoner and Zha (1999)

Note: Panel (a): Benchmark forecasts are in yellow and those under the scenario in purple. Shaded areas correspond to 68% and 90% moving block bootstrap confidence intervals. The real oil price, interest rate and exchange rate are reported in levels and other variables are shown in year-over-year growth rates. Panel (b): Decomposition of the forecasts according to implied structural shocks from equation (14).

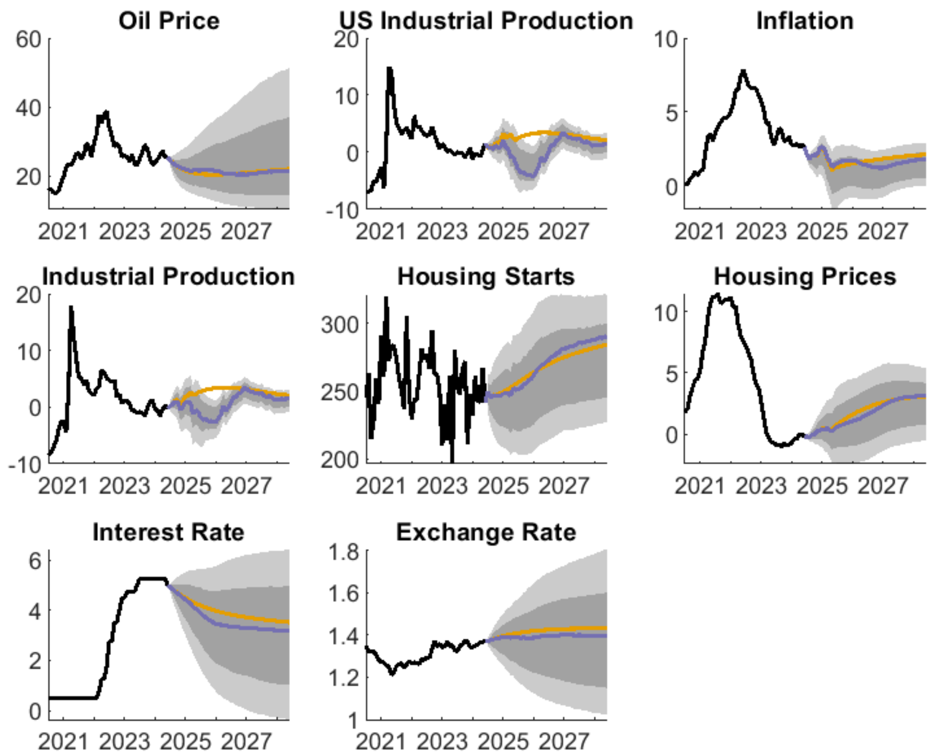


Figure 6: US Economy Slowdown Scenario with Baumeister and Kilian (2014)

Note: Benchmark forecasts are in yellow and those under the scenario in purple. Shaded areas correspond to 68% and 90% moving block bootstrap confidence intervals. The real oil price, interest rate and exchange rate are reported in levels and other variables are shown in year-over-year growth rates.

These results align well qualitatively with those of other studies analyzing how adverse shocks in the United States negatively impact various sectors of the Canadian economy, notably from Miyamoto and Nguyen (2017) (adverse technological shocks in the United States), Bedock and Stevanovic (2017) (credit shocks), Moran et al. (2022) (uncertainty shocks) or Moran et al. (2023) (shocks to American confidence).

The scenarios analyzed in this section provide a framework for assessing risks by constructing quantitative narratives about potential future events that could cause deviations from baseline forecasts, thereby influencing the Canadian economy.

5 Conclusion

This paper demonstrates the value of conditional forecasting in understanding the potential risks facing the Canadian economy. By simulating scenarios for monetary policy, oil prices, and a U.S. recession, we uncover distinct pathways through which these shocks influence macroeconomic variables. The analysis highlights the importance of external factors, such as global oil prices and U.S. economic conditions, in driving Canadian economic fluctuations. Rising oil prices generate positive demand shocks that bolster industrial production, housing markets, and the exchange rate, while a U.S. recession leads to cascading negative effects, exacerbated by falling oil prices and close trade linkages between the two countries.

The structural decomposition of shocks provides further insight, revealing how oil price dynamics amplify both positive and negative demand effects, and how they disproportionately influence housing activity. These results underscore the interconnected nature of macroeconomic variables in a small open economy and the need for adaptive and proactive policy measures to mitigate the risks posed by external shocks. Future research could explore additional scenarios, incorporate sectoral details, or examine how these risks evolve under changing economic conditions. Such extensions would enhance our ability to forecast and manage the uncertainties that shape Canada's economic outlook.

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A Additional Results

The Appendix contain a variety of additional results mentioned in the paper. Below, Table 1 presents the variance decomposition for the benchmark VAR model we used to produce the scenarios in the paper.

Table 1: Variance Decomposition

Horizon	CPI	Housing Starts	Housing Prices	Production	Bank Rate	Exchange Rate
Panel A: Shock to oil prices						
3 months	32.4	8.6	4.1	29	2.4	20.2
	[24.8, 40.1]	[2, 15.5]	[1.3, 7.5]	[1.1, 57.3]	[0.1, 13.7]	[11.6, 30.4]
12 months	29.6	12.2	4.9	30.7	2.8	18.4
	[16.8, 37.1]	[3.5, 21.4]	[0.8, 14.3]	[1.7, 58.5]	[0.2, 20.8]	[6.7, 32.9]
24 months	22.1	11.6	3.7	26	2.5	14.4
	[9.9, 32.3]	[3.5, 20.6]	[0.6, 16.5]	[1.9, 51.3]	[0.4, 22.7]	[4.9, 32.2]
48 months	12.8	11.1	2.6	19.6	2	10.6
	[4.8, 24.9]	[3.5, 20.2]	[0.5, 17.7]	[2, 45.3]	[0.5, 22.5]	[4.2, 30.8]
Panel B: Shock to US economic activity						
3 months	1.6	0.8	0.2	30	1.5	1.7
	[0.1, 6.2]	[0.4, 4.2]	[0, 4]	[16.1, 35.3]	[0.2, 6.8]	[0.3, 5.9]
12 months	1.1	0.5	0.7	36	1.7	1
	[0.3, 6.6]	[0.5, 6.9]	[0.1, 7.5]	[19.4, 47.4]	[0.3, 10.4]	[0.2, 9.3]
24 months	1.1	0.7	0.6	40.6	1.5	0.8
	[0.6, 13.2]	[0.6, 7.6]	[0.1, 10]	[19.6, 51.3]	[0.3, 11.8]	[0.3, 13.2]
48 months	1.9	0.8	0.3	36.2	1.2	0.6
	[0.6, 19.7]	[0.7, 7.9]	[0.1, 13.6]	[18.1, 50]	[0.5, 13.1]	[0.4, 16.7]
Panel C: Shock to Canadian monetary policy						
3 months	0.1	0	0.8	1.3	94.5	0.2
	[0, 0.9]	[0, 0.9]	[0, 3]	[0.1, 3.9]	[80.7, 95.4]	[0, 2.2]
12 months	0.2	1.5	4.8	1.1	90.8	2
	[0, 3.1]	[0.3, 12.6]	[0.4, 18]	[0.3, 5.3]	[64.4, 91.7]	[0.1, 7.2]
24 months	0.2	4.5	13	1.5	87.3	4.9
	[0.1, 9.5]	[0.6, 21.2]	[1.3, 37.4]	[0.5, 11.1]	[54, 89.5]	[0.2, 16.1]
48 months	2.7	5.4	28.1	1.9	81.5	9.9
	[0.5, 27.6]	[0.8, 22.2]	[3.1, 51.6]	[1, 13.2]	[46, 86.6]	[0.4, 26.5]

Note: The decomposition is performed for the transformed variables in the benchmark model. The 95% confidence intervals obtained with 2000 replications of a moving block residual bootstrap are shown in the square brackets.

Using the reduced-form residuals from our benchmark model $\hat{\mathbf{u}}_t$ and the structural impact matrix we identify using short-run recursive restrictions $\hat{\mathbf{D}}$, we can recover an estimate of the series of realized structural as $\hat{\epsilon}_t = \hat{\mathbf{D}}^{-1}\hat{\mathbf{u}}_t$. Figure 7 displays the identified monetary policy shock. Cumulated values reveal sequences of shocks that were particularly positive and negative. This is how we selected a sequence of shocks for the Baumeister and Kilian (2014) monetary policy scenario shown in Figure 2.

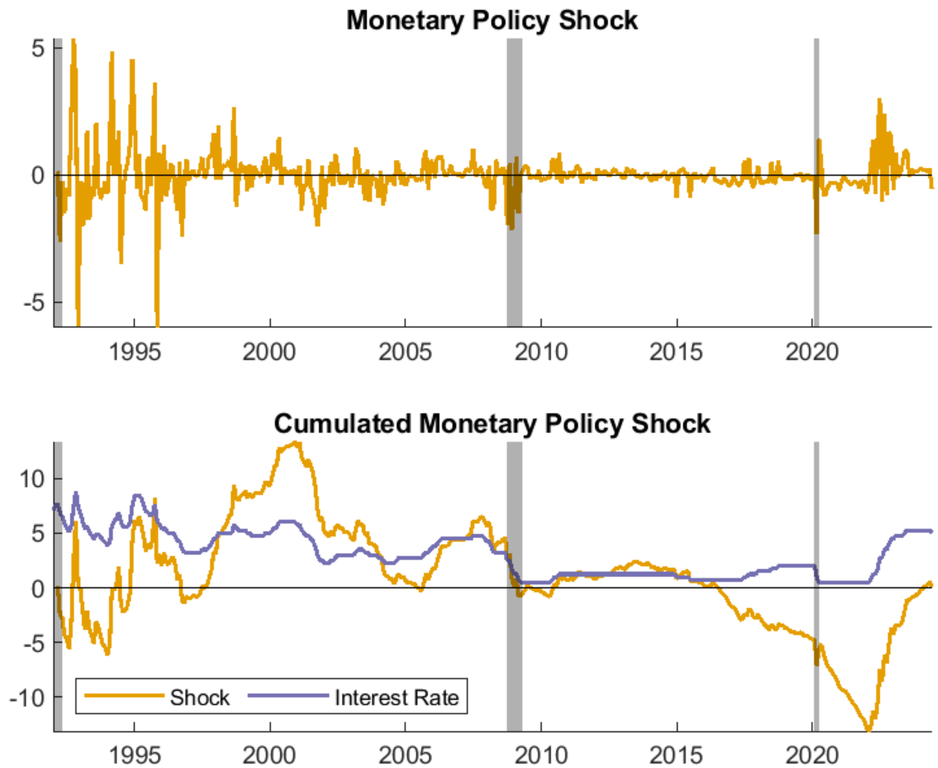
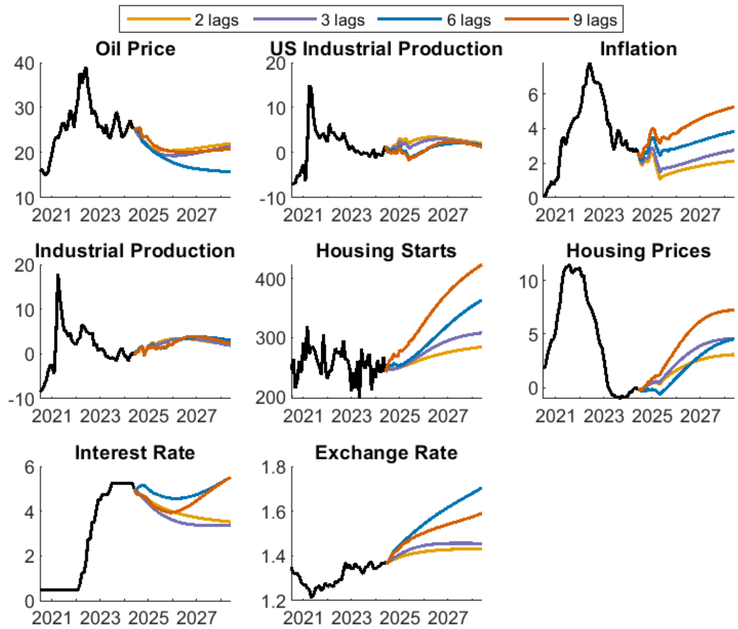


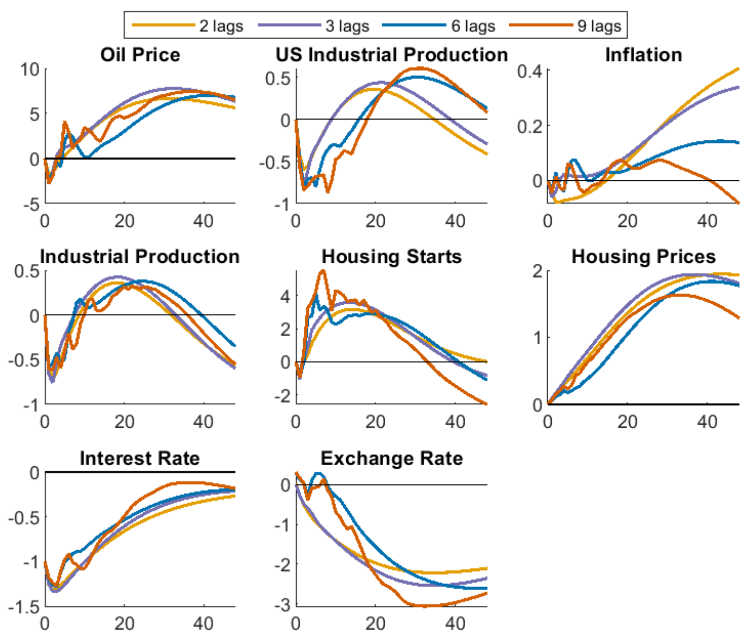
Figure 7: Identified Monetary Policy Shocks

Note: The shock sequence is obtained using block-recursive short-run restrictions in the benchmark VAR model. The shaded areas are CD Howe recession dates.

Next, since the prevalence of longer lag structure in the structural VAR literature, we explore the sensitivity of our results to using different lag lengths. Given our limited sample, the number of variables involved and the fact that even AIC chooses only 2 lags, we explored the sensitivity of our results to using 3, 6 or 9 months of lags. The unconditional forecasts and impulses responses to a monetary policy shock are displayed in Figure 8.



Unconditional Forecasts



Responses to a 100 BPS Interest Rate Cut

Figure 8: Forecast Comparison

Note: All models were estimated by OLS in levels with a constant on monthly data between January 1992 and June 2024. The model with two lags corresponds to our benchmark. Monetary policy shocks are identified using block recursive short-run restrictions as in the benchmark model.