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Bank of Canada Quarterly Research Update

2023Q4

This quarterly newsletter features the latest research publications by Bank of Canada economists. The report includes papers appearing in external publications and staff working papers published on the Bank of Canada's website.

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Serdar Birinci & **Kurt See**, "Labour Market Responses to Unemployment Insurance: The Role of Heterogeneity", *American Economic Journal: Macroeconomics*, Vol. 14(3): 388-430, July 2023

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ABSTRACTS

In-Press Published Papers

Bitcoin Awareness, Ownership and Use: 2016-20

Since 2016, the Bank of Canada has conducted annual surveys to monitor awareness, adoption and usage of Bitcoin and other cryptocurrencies. This report incorporates results from the 2019 Bitcoin Omnibus Survey and the November 2020 Cash Alternative Survey. We find that between 2018 and 2020, the level of Bitcoin awareness and ownership among Canadians remained stable: nearly 90% of the population were aware of Bitcoin, while only 5% owned it. We find that about half of Bitcoin owners stated they usually obtained their bitcoins through mobile or web exchanges, while one-fifth used mining. Bitcoin owners were susceptible to certain risks, as evidenced by the fact that about half of current and past owners stated they had been affected by events such as price crashes, losing access to funds, scams or data breaches. The most commonly cited reasons for owning Bitcoin were related to its use for investment or based on interest in the technology. Bitcoin owners displayed greater knowledge about the Bitcoin network than nonowners, yet they scored lower on questions testing financial literacy.

Self-Harming Trade Policy? Protectionism and Production Networks

Using monthly data on temporary trade barriers (TTBs), we estimate the dynamic employment effects of protectionism through vertical production linkages. First, exploiting high-frequency data and TTB procedural details, we identify trade policy shocks exogenous to economic fundamentals. We then use input-output tables to construct measures of protectionism affecting downstream producers. Finally, we estimate panel local projections using the identified trade policy shocks. Protectionism has small and insignificant beneficial effects in protected industries. The effects in downstream industries are negative, sizable, and significant. The employment decline follows an increase in intermediate input and final goods prices and a decline in stock market returns.

Labour Market Responses to Unemployment Insurance: The Role of Heterogeneity

We document considerable scope of heterogeneity within the unemployed, especially when they are divided along eligibility for and receipt of unemployment insurance (UI). We study the implications of this heterogeneity on UI's insurance-incentive trade-off using a heterogeneous-agent job search model capable of matching the

wealth and income differences that distinguish UI recipients from nonrecipients. Insurance benefits are larger for UI recipients who are predominantly wealth poor. Meanwhile, incentive costs are nonmonotonic in wealth because the poorest individuals, who value employment, exhibit weak responses. Differential elasticities imply that accounting for the composition of recipients is material to the evaluation of UI's insurance-incentive trade-off.

The Contribution of Firm Profits to the Recent Rise in Inflation

We measure the contribution to inflation from the growth in markups of Canadian firms. The dynamics of inflation and markups suggest that changes in markups could account for less than one-tenth of inflation in 2021. Further, they suggest that peak inflation was driven primarily by changes in firms' costs.

The Long-Run Redistributive Effects of Monetary Policy

Using a general equilibrium search-theoretic model of money, I study the long-run distributional effects of monetary policy. In my model, heterogeneous agents trade bilaterally in a frictional market and save using cash and illiquid short-term nominal government bonds. Wealth effects generate slow adjustments in agents' portfolios following their trading activity in decentralized markets, giving rise to a persistent and non-degenerate distribution of assets. The model reproduces the distribution of asset levels and portfolios across households observed in the data. I show that, as wealth inequality increases the incidence of inefficiencies in decentralized trading, policies that improve the ability to self-insure against idiosyncratic shocks are welfare-improving and redistribute resources towards agents that are relatively poor and more liquidity constrained.

Macroeconomic Predictions Using Payments Data and Machine Learning

This paper assesses the usefulness of comprehensive payments data for macroeconomic predictions in Canada. Specifically, we evaluate which type of payments data are useful, when they are useful, why they are useful, and whether machine learning (ML) models enhance their predictive value. We find payments data with a factor model can help improve accuracy up to 25% in predicting GDP, retail, and wholesale sales; and nonlinear ML models can further improve the accuracy up to 20%. Furthermore, we find the retail payments data are more useful than the data from the wholesale system; and they add more value during crisis and at the nowcasting horizon due to the timeliness. The contribution of the payments data and ML models is small and linear during low and normal economic growth periods.

However, their contribution is large, asymmetrical, and nonlinear during crises such as COVID-19. Moreover, we propose a cross-validation approach to mitigate overfitting and use tools to overcome interpretability in the ML models to improve their effectiveness for policy use.

Covid-19 and Implications for Automation

COVID-19 may accelerate the automation of jobs as employers invest in technology to safeguard against pandemics. We identify occupations that have high automation potential and also exhibit a high risk of viral infection. We examine regional variation in terms of which U.S. local labour markets are most at risk. Next, we outline the differential impacts COVID-19 may have on different demographic groups. We find that the highest-risk occupations in the U.S. are those held by females with mid- to low-wage and education levels. Using comparable data for 25 other countries, we also find that women in this demographic are at the highest risk internationally.

Central Bank Digital Currency and Banking: Macroeconomic Benefits of a Cash-Like Design

Many central banks are considering issuing a central bank digital currency (CBDC). How will the CBDC affect the macroeconomy? Will its design matter? To answer these questions, we theoretically and quantitatively assess the effects of a CBDC on consumption, banking, and welfare. Our model captures the competition between different means of payments and incorporates a novel general equilibrium feedback effect from transactions to deposits creation. The general equilibrium effects of a CBDC are decomposed into three channels: payment efficiency, price effects, and bank funding costs. We show that a cash-like CBDC is more effective than a deposit-like CBDC in promoting consumption and welfare. Interestingly, a cash-like CBDC can also crowd in banking, even in the absence of bank market power. In a calibrated model, at the maximum, a cash-like CBDC can increase bank intermediation by 10.2% and welfare by 0.059%, and it can capture up to 23.3% of the payment market. We also discuss some lessons for designing a CBDC.

Monetary Policy Transmission and Policy Coordination in China

We study the transmission of conventional monetary policy in China, focusing on the interaction between monetary and fiscal policy given the unique institutional set-up for macroeconomic policy making. Our results suggest some progress but also continued difficulties in the transmission of monetary policy. Similar to recent studies, we find evidence of monetary policy pass-through to interest rates. However,

the impact of monetary policy measures that are not coordinated with fiscal policy is significantly weaker than that of coordinated measures. This suggests the need for further improvements to the interest-rate based framework.

Identifying Sectoral Shocks and Their Role in Business Cycles

US business cycles can be empirically characterized as a time-varying mix of different sectoral shocks. Sectoral shocks are distinct from aggregate shocks and better capture business cycle fluctuations. A typical recession (or boom) is interpreted as the combination of a few sectoral shocks, which encompass more diverse origins than the typical narrative prevalent for that recession. Sectoral shocks have aggregate consequences through strong input–output network effects. Identification is based on network-implied heterogeneity restrictions in a FAVAR framework and far less dependent on specific DSGE calibrations compared to previous work.

Futures Prices are Useful Predictors of the Spot Price of Crude Oil

How well do futures prices forecast the spot price of crude oil? Contrary to the established view, futures prices significantly improve upon the accuracy of monthly no-change forecasts. This results from two innovations. First, we document that independent of the construction of futures-based forecasts, longer-horizon futures prices have become better predictors of crude oil spot prices since the mid-2000s. Second, we show that futures curves constructed using end-of-month prices instead of average prices have consistently been able to generate large accuracy-improvements for short-horizon forecasts of average prices. These findings are remarkably robust and apply to all major crude oil benchmarks.

Forecasting Returns Instead of Prices Exacerbates Financial Bubbles

Expectations of future returns are pivotal for investors' trading decisions, and are therefore an important determinant of the evolution of actual returns. Evidence from individual choice experiments with exogenously given time series of returns suggests that subjects' return forecasts are substantially affected by how they are elicited and by the format in which subjects receive information about past asset performance. In order to understand the impact of these effects found at the individual level on market dynamics, we consider a learning to forecast experiment where prices and returns are endogenously determined and depend directly upon subjects' forecasts. We vary both the variable (prices or returns) subjects observe and the variable (prices or returns) they have to forecast, with the same underlying data generating process for each treatment.

Although there is no significant effect of the presentation format of past information, we do find that markets are significantly more unstable when subjects have to forecast returns instead of prices. Our results therefore show that the elicitation format may exacerbate, or even create, bubbles and crashes in financial markets.

Understanding Post-Covid Inflation Dynamics

We propose a macroeconomic model with a nonlinear Phillips curve that has a flat slope when inflationary pressures are subdued and steepens when inflationary pressures are elevated. The nonlinear Phillips curve in our model arises due to a quasi-kinked demand schedule for goods produced by firms. Our model can jointly account for the modest decline in inflation during the Great Recession and the surge in inflation during the post-COVID period. Because our model implies a stronger transmission of shocks when inflation is high, it generates conditional heteroskedasticity in inflation and inflation risk. Hence, our model can generate more sizeable inflation surges due to cost-push and demand shocks than a standard linearized model. Finally, our model implies that the central bank faces a more severe trade-off between inflation and output stabilization when inflation is elevated.

Behavioural Learning Equilibria in New Keynesian Models

We introduce Behavioral Learning Equilibria (BLE) into a multivariate linear framework and apply it to New Keynesian DSGE models. In a BLE, boundedly rational agents use simple, but optimal AR(1) forecasting rules whose parameters are consistent with the observed sample mean and autocorrelation of past data. We study the BLE concept in a standard 3-equation New Keynesian model and develop an estimation methodology for the canonical Smets and Wouters (2007) model. A horse race between Rational Expectations (REE), BLE, and constant gain learning models shows that the BLE model outperforms the REE benchmark and is competitive with constant gain learning models in terms of in-sample and out-of-sample fitness. Sample-autocorrelation learning of optimal AR(1) beliefs provides the best fit when short-term survey data on inflation expectations are taken into account in the estimation. As a policy application, we show that optimal Taylor rules under AR(1) expectations inherit history dependence and require a lower degrees of interest rate smoothing than REE.

Reassessing Trade Barriers with Global Production Networks

This paper develops a two-country general equilibrium model with forward-looking participation decisions on exporting and multinational

production, and examines the effects of final-goods tariffs and intermediate-input tariffs. I show that permanent unilateral tariffs lead to a recession in the policy-imposed country. In the policy-imposing country, investment experiences a short-run boom while consumption falls immediately and persistently, with intermediate-input tariffs resulting in a larger contraction. At the firm level, the least productive exporters exit from the policy-imposing country, while the most productive ones relocate production there. Relative to a model without multinational firms, this production relocation partially offsets the contractionary effects of tariffs. Crucial to the short-run investment expansion and firms' participation in multinational production in the policy-imposing country is the persistence of tariffs. When tariffs are temporary, investment falls immediately, driving an immediate recession there, in contrast to permanent tariffs. Further, temporary tariffs induce hysteresis in firms' participation in exporting and multinational production, which in turn diminishes the expansionary effects of multinational entry.

Forward Guidance and Expectation Formation: A Narrative Approach

How forward guidance influences expectations is not fully understood. To study this, I construct central bank data that includes forward guidance and its attributes, central bank projections, and quantitative easing, which I combine with survey data. I describe how, when, and where forward guidance has worked. I estimate that forecasters revised their interest rate forecasts in the intended direction by five basis points on average following a forward guidance change. I provide estimates for The Federal Reserve, European Central Bank, Bank of England, Bank of Canada, Reserve Bank of Australia, Reserve Bank of New Zealand, Sveriges Riksbank, and Norges Bank.

A Horse Race of Alternative Monetary Policy Regimes Under Bounded Rationality

We introduce bounded rationality, along the lines of Gabaix (2020), in a canonical New Keynesian model calibrated to match Canadian macroeconomic data. We use the model to provide a quantitative assessment of the macroeconomic impacts of alternative monetary policy regimes—flexible inflation targeting (FIT), average-inflation targeting (AIT) and price-level targeting (PLT)—with an effective lower bound (ELB) constraint. First, our results suggest that the benefits of adopting history-dependent monetary policy regimes rely on two important assumptions: rational expectations and the central bank's emphasis in stabilizing real variables such as the output gap. The macro-stabilization advantage of PLT disappears even for small

deviations from rational expectations, and it is especially undermined when the central bank assigns a high weight on output volatility. Second, the presence of cost-push shocks, such as the ones global economies have experienced since the recovery from the pandemic, introduces important policy trade-offs that poses practical challenges which are best tackled using an AIT regime. Third, in choosing the optimal window width under the AIT regime, a central bank that assigns some emphasis on real sector stability needs to be mindful of expectation formation. If economic agents are sufficiently far from being rational, our simulations indicate that the optimal window is between 1 and 2.5 years.

The Countercyclical Capital Buffer and International Bank Lending: Evidence from Canada

We examine the impact of the recently introduced Basel III countercyclical capital buffer (CCyB) on foreign lending activities of Canadian banks. By exploiting the variation in CCyB rates across countries, we overcome the identification challenge associated with limited time-series evidence on the CCyB's use in individual jurisdictions. We show that in response to a 1-percentage-point tightening announcement in a foreign CCyB, the growth rate of cross-border lending between Canadian banks and borrowers abroad decreases by 12-17 percentage points. The direction of this effect is likely driven by the CCyB's unique reciprocity rule, which also subjects foreign banks to domestic regulation.

Forthcoming Published Papers

The Exchange Rate Elasticity of Exports: A Shock-Dependent Approach

Understanding and predicting the evolution of exports after a change in the nominal exchange rate is of central importance in international economics. Most of the literature focuses on estimating this relationship by reduced form, with the aim of uncovering a single structural parameter, but theory suggests it could differ depending on the shock that drives the movement in the exchange rate. Building on this insight, we develop a small-open-economy SVAR model to derive structural shocks that affect the exchange rate. We then estimate this model using Canadian data and construct the response of exports relative to the response of the exchange rate, conditional on each shock. Our findings suggest that this relationship differs greatly from one shock to another, where domestic shocks generate a much weaker relationship than global shocks. We show that these differences can be reconciled with theoretical results from a small-

open-economy New Keynesian model where Canadian exports are largely invoiced in US dollars. Finally, we highlight how our results help to inform recent discussions on the evolution of the exchange rate elasticity over time, the benefits of a flexible exchange rate, and the impact of terms of trade movements on exports

Dynamic Competition in Negotiated Price Markets

This paper develops a framework for investigating dynamic competition in markets where price is negotiated between an individual customer and multiple firms repeatedly. Using contractlevel data for the Canadian mortgage market, we provide evidence of an "invest-then-harvest" pricing pattern: lenders offer relatively low interest rates to attract new borrowers and poach rivals' existing customers, and then at renewal charge interest rates which can be higher than what may be available through other lenders in the marketplace. We build a dynamic model of price negotiation with search and switching frictions to capture key market features. We estimate the model and use it to investigate (i) the effects of dynamic competition on borrowers' and banks' payoffs, (ii) the implications of dynamic versus static settings for mergerstudies, and (iii) the impacts from recent Canadian macroprudential policies.

A Simple Model of Global Fuel Consumption

We present an SVAR model of the global oil market that utilizes information on global oil consumption in the form of fuels. Under mild identifying assumptions, data on global fuel consumption provides comparatively sharp insights into structural parameters of the global oil market. The estimated short-run global fuel demand elasticity with respect to crude oil prices is around -2%, which is considerably more inelastic than estimates of local fuel demand elasticities based on disaggregated data. Our framework provides new evidence on the drivers of oil-market dynamics and on the effects of climate change policies that act through the price of oil.

Disentangling the Supply and Announcement Effects of Open Market Operations

Central banks use open market operations (OMOs) to adjust the liquidity available to the financial system to maintain the short-term borrowing rate within the desired target range. Using the conditional event study methodology to decompose the impact of OMOs into supply and announcement effects, this paper finds that when OMO announcements are unexpected, the decrease in the lending rate as a result of the higher supply is significantly moderated by the announcement effect. The results highlight that central banks

communicate not just through signals of their desired policy stance, but also through their announcements of operations that implement the stance.

Combining Large Numbers of Density Predictions with Bayesian Predictive Synthesis

Bayesian Predictive Synthesis is a flexible method of combining density predictions. The flexibility comes from the ability to choose an arbitrary synthesis function to combine predictions. I study choice of synthesis function when combining large numbers of predictions – a common occurrence in macroeconomics. Estimating combination weights with many predictions is difficult, so I consider shrinkage priors and factor modelling techniques to address this problem. These techniques provide an interesting contrast between the sparse weights implied by shrinkage priors and dense weights of factor modelling techniques. I find that the sparse weights of shrinkage priors perform well across exercises.

Unmet Payment Needs and a Central Bank Digital Currency

We discuss the payment habits of Canadians both in the current payment environment and in a hypothetical cashless environment. We also consider whether a central bank digital currency (CBDC) would address unmet payment needs in a cashless society. Most adult Canadians do not experience gaps in their access to a range of payment methods, and this would probably continue to be the case in a cashless environment. Some people could, however, face difficulties making payments if merchants no longer generally accepted cash as a method of payment. For a payment-oriented CBDC to successfully address unmet payment needs, the main consumer groups — who already have access to a range of payment options — would have to widely adopt the CBDC and use it at scale. This is necessary to encourage widespread merchant acceptance of CBDC, which would, in turn, encourage further consumer adoption and use. Most consumers, however, face few payment gaps or frictions and therefore might have relatively weak

Explaining Bitcoin Ownership in Canada: Trends from 2016 to 2021

incentives to adopt and — especially — to use CBDC at scale. If that were the case, widespread merchant acceptance would also be unlikely. This suggests that addressing unmet payment needs for a minority of consumers by issuing a CBDC could be challenging under the conditions explored in this paper. The minority of consumers with unmet payment needs will only be able to benefit from a CBDC if the majority of consumers experience material benefits and therefore

drive its use. Adoption by the majority may have added policy implications that are beyond the scope of this paper.

Monetary Policy and the Persistent Aggregate Effects of Wealth Redistribution

We identify a wealth redistribution channel which creates a monetary policy trade-off whereby short-term economic stimulus is followed by persistently lower output over the medium term. This trade-off is stronger in economies with more nominal household debt but weakened by a more aggressive monetary policy stance and under price-level targeting. Given this channel, negative supply shocks become more severe and persistent. The interaction of heterogeneous labor supply with heterogeneous net nominal asset positions of households is crucial for the medium-term implications of this channel, which we show analytically and in the context of an estimated New Keynesian general equilibrium model with household heterogeneity.

Job Applications and Labor Market Flows

Job applications have risen over time yet job-finding rates remain unchanged. Meanwhile, separations have declined. We argue that increased applications raise the probability of a good match rather than the probability of job-finding. Using a search model with multiple applications and costly information, we show that when applications increase, firms invest in identifying good matches, reducing separations. Concurrently, increased congestion and selectivity over which offer to accept temper increases in job-finding rates. Our framework contains testable implications for changes in offers, acceptances, reservation wages, applicants per vacancy, and tenure, objects that enable it to generate the trends in unemployment flows.

Staff Working Papers

Intermediary Market Power and Capital Constraints

We examine how intermediary capitalization affects asset prices in a framework that allows for intermediary market power. We introduce a model in which capital-constrained intermediaries buy or trade an asset in an imperfectly competitive market, and we show that weaker capital constraints lead to both higher prices and intermediary markups. In exchange markets, this results in reduced market liquidity, while in primary markets it leads to higher auction revenues at an implicit cost of larger price distortion. Using data from Canadian Treasury auctions, we demonstrate how our framework can quantify

these effects by linking asset demand to individual intermediaries' balance sheet information.

Labour Market Shocks and Monetary Policy

We develop a heterogeneous-agent New Keynesian model featuring a frictional labor market with on-the-job search to quantitatively study the positive and normative implications of employer-to-employer (EE) transitions for inflation. We find that EE dynamics played an important role in shaping the differential inflation dynamics observed during the Great Recession and COVID-19 recoveries, with the former exhibiting subdued EE transitions and inflation despite both episodes sharing similar unemployment dynamics. The optimalmonetary policy prescribes a strong positive response to EE fluctuations, implying that central banks should distinguish between recovery episodes with similar unemployment but different EE dynamics.

Identifying Nascent High-Growth Firma Using Machine Learning

Predicting which firms will grow quickly and why has been the subject of research studies for many decades. Firms that grow rapidly have the potential to usher innew innovations, products or processes (Kogan et al. 2017), become superstar firms (Haltiwanger et al. 2013) and impact the aggregate labour share (Autor et al. 2020; De Loecker et al. 2020). We explore the use of supervised machine learning techniques to identify a population of nascent high-growth firms using Canadian administrative firm-level data. We apply a suite of supervised machine learning algorithms (elastic net model, random forest and neural net) to determine whether a large set of variables on Canadian firm tax filing financial and employment data, state variables (e.g., industry, geography) and indicators of firm complexity (e.g., multiple industrial activities, foreign ownership) can predict which firms will be high-growth firms over the next three years. The results suggest that the machine learning classifiers can select a sub-population of nascent high-growth firms that includes the majority of actual high-growth firms plus a group of firms that shared similar attributes but failed to attain high-growth status

Borrow Now, Pay Even Later: A Quantitative Analysis of Student Debt Payment Plans

In the United States, student debt currently represents the second largest component of consumer debt, just after mortgage loans. Repayment of those loans reduces disposable income early in the borrower's lifecycle, when marginal utility is particularly high, and limits their ability to build a buffer stock of wealth to insure against background risks. In this paper, we study alternative student debt

contracts that offer a 10-year deferral period. Borrowers defer either principal payments only (“Principal Payment Deferral”, PPD) or all payments (“Full Payment Deferral”, FPD) with the missed interest payments added to the value of the debt outstanding. We first calibrate an equilibrium with the current contracts, and then solve for counterfactual equilibria with the PPD or FPD contracts. We find that both alternatives generate economically large welfare gains, which are robust to different assumptions about the behavior of the lenders and borrower preferences. We decompose the gains into the percentages resulting from loan repricing and from the deferral of debt repayments. We compare these alternative contracts with the changes to Income Driven Repayment Plans being proposed by the current U.S. administration and show that they dominate such proposals. Crucially, the PPD and FPD contracts deliver similar welfare gains to the debt relief program considered by the administration, with no impact on the government budget constraint.

Uncovering the Differences Among Displaced Workers: Evidence from Canadian Job Separation Records

We revisit the measurement of the sources and consequences of job displacement using Canadian job separation records. To circumvent administrative data limitations, conventional approaches address selection by identifying displacement effects through mass-layoff separations, which are interpreted as involuntary. We refine this procedure and find that only a quarter of mass-layoff separations are indeed layoffs. Isolating mass-layoff separations that reflect involuntary displacement, we find twice the earnings losses relative to existing estimates. We uncover heterogeneity in losses for separations with different reasons and timing, ranging from 15 percent for quits after a mass layoff to 60 percent for layoffs before it.

International Portfolio Rebalancing and Fiscal Policy Spillovers

We evaluate, both empirically and theoretically, the spillover effects that debt-financed fiscal policy interventions of the United States have on other economies. We first consider a twocountry dynamic stochastic general equilibrium model with international portfolio rebalancing effects arising from an imperfect substitutability between short- and long-term domestic and foreign bonds. The model shows that US fiscal expansions financed by longterm debt issuance would, on net, hinder economic activity in the rest of the world (ROW). This is despite the standard trade channel’s net positive effect on the ROW economy given the depreciation in the ROW currency. The fall in ROW output occurs mainly due to the increase in the ROW term premia and long-term rates through the portfolio rebalancing channel.

This is because the relative demand for ROW long-term bonds decreases following the increase in the supply of US long-term bonds accompanying the fiscal expansion. Testing the predictions of our theoretical model by using panel regressions and vector autoregressions, we find empirical support for the negative relationship between ROW output and US fiscal spending. The data also confirm the positive relationship between ROW term spreads and US fiscal spending.

Immigration and Provision of Public Goods: Evidence at the Local Level in the U.s.

Using U.S. county-level data from 1990 to 2010, we study the causal impact of immigration on the provision of local public goods. We uncover substantial heterogeneity across immigrants with different skills, mainly due to the asymmetric impact immigrants have on the per capita tax base and local revenues. In the absence of full insurance through intergovernmental transfers, the changes in per capita revenues are reflected in changes in the provision of local public services: per capita public expenditures decrease with the arrival of low-skilled immigrants and increase with the arrival of high-skilled immigrants. While the two types of immigrants offset each other on average, spatial differences in the population shares of low- and high-skilled immigrants lead to unequal fiscal effects across U.S. counties. We find the estimated impact to differ across various public services and for second-generation immigrants.

Testing Collution and Cooperation in Binary Choice Games

This paper studies the testable implication of players' collusive or cooperative behaviours in a binary choice game with complete information. In this paper, these behaviours are defined as players coordinating their actions to maximize the weighted sum of their payoffs. I show that this collusive model is observationally equivalent to an equilibrium model that imposes two restrictions. The first restriction is on each player's strategic effect and the second one requires a particular equilibrium selection mechanism. Under the equilibrium condition, these joint restrictions are simple to test using tools in the literature on empirical games. This test, as suggested by the observational equivalence result, is the same as testing collusive and cooperative behaviours. I illustrate the implementation of this test by revisiting the entry game between Walmart and Kmart studied by Jia (2008). Under the equilibrium condition, Jia's original estimates are consistent with the first restriction on the strategic effects, serving as a warning sign of potential collusion. This paper tests and rejects the second restriction on the equilibrium selection mechanism. Thus,

the empirical evidence suggests that Walmart and Kmart did not collude on their entry decisions.

Perceived Versus Calibrated Income Risks in Heterogeneous-Agent Consumption Models

Models of microeconomic consumption (including those used in heterogeneous-agent macroeconomic models) typically calibrate the size of income risk to match panel data on household income dynamics. But, for several reasons, what is measured as risk from such data may not correspond to the risk perceived by the agent. This paper instead uses data from the Federal Reserve Bank of New York's Survey of Consumer Expectations to directly calibrate perceived income risks. One of several examples of the implications of heterogeneity in perceived income risks is increased wealth inequality stemming from differential precautionary saving motives. I also explore the implications of the fact that the perceived risk is lower than the calibrated level of risk either because of unobserved heterogeneity by researchers or because of overconfidence by the agents.

Third-Country Effects of U.s. Immigration Policy

We study how the effects of U.S. restrictions on skilled immigration affect the Canadian economy and American workers' welfare. In 2017, the United States implemented a policy that tightened the eligibility criteria for U.S. visas. This was followed immediately by a trend break in the number of skilled immigrant admissions to Canada. We use quasi-experimental variation introduced by this policy over time and across immigrant groups, along with U.S. and Canadian visa applications data, to show that in 2018 visa applications for moving to Canada increased by 30% relative to the period before the restrictions were imposed. We then study how the restrictions affected Canadian firms. We use comprehensive Canadian administrative databases containing the universe of employer-employee linked records, immigration records, and international trade data. We find that Canadian firms that were relatively more exposed to the inflow of immigrants increased production, exports, and employment of Canadian workers. Finally, we study the policy's impact on American workers by incorporating immigration policy into a multi-sector international trade model. With international trade, the increase in immigration to other countries due to the restrictions affects American wages through U.S. exports and consumption prices. We calibrate the model using our novel data and reduced-form estimates. We find that the welfare gains for American workers targeted for protection by the 2017 policy are up to 25% larger in a

closed economy than they are in an open economy with the observed trade levels.

Predictive Density Combination Using a Tree-Based Synthesis Function

Bayesian predictive synthesis (BPS) is a method of combining predictive distributions based on agent opinion analysis theory, which encompasses many common approaches to combining density forecasts. The key ingredient in BPS is a synthesis function. This is typically specified parametrically as a dynamic linear regression. In this paper, we develop a nonparametric treatment of the synthesis function using regression trees. We show the advantages of our tree-based approach in two macroeconomic forecasting applications. The first uses density forecasts for GDP growth from the euro area's Survey of Professional Forecasters. The second combines density forecasts of US inflation produced by many regression models involving different predictors. Both applications demonstrate the benefits—in terms of improved forecast accuracy and interpretability—of modeling the synthesis function nonparametrically.

Monetary Policy and Racial Inequality in Housing Markets: A Study of 140 Us Metropolitan Areas

This paper investigates the differential impact of monetary policy on homeownership and housing returns among Black, Hispanic and White households. Using data on 13 million repeat sales from 1993 to 2020, we construct and analyze race-specific entries and exits of homeownership and housing returns for 140 metropolitan areas in the United States. Our findings reveal significant heterogeneity: for minority households, one unit of monetary tightening leads to a 15% lower housing return and a 31% lower entry into homeownership than White households. This heterogeneity primarily stems from the less favorable labor market responses of minority groups to contractionary monetary policy. These findings emphasize the unintended consequences of monetary policy on racial inequality in the housing market.

The Effects of Communicating Inflation Uncertainty on Household Expectations

This paper examines the value of direct communication to households about inflation and the uncertainty around inflation statistics. All types of information about inflation are effective at immediately managing inflation expectations, with information about outlooks being more effective and more relevant than that about recent inflation and Bank targets. We observe no downside to

communicating about inflation with uncertainty on two measures: the level of expected inflation and uncertainty about it. On a third measure—probabilistic inflation expectations—we observe positive effects: they become more centered around the communicated ranges. However, communication with uncertainty weakens the link between expected inflation and spending plans, a key channel in the transmission of monetary policy. Communicating precise inflation outlooks can lengthen the effects of these communications on households.

Staff Discussion Papers

Redefining Financial Inclusion for a Digital Age: Implications for a Central Bank Digitial Currency

Digitalization—the use of data, digital platforms and advanced analytics—has quickly become widespread in today's society. This has introduced new opportunities, but it has also created new barriers and exacerbated existing inequities. This is likewise true in the realm of payments, where issues around financial inclusion, digital inclusion and accessibility compound the challenges for users. Our work expands on that of Henry et al. (2023). We base our research on two key premises. First, we apply the social model of disability to the Canadian payments landscape to identify opportunities to remove barriers that marginalize or hinder people. Second, we investigate beyond the standard economic measures and aggregate statistics related to these topics to build a nuanced understanding of the challenges inherent in the current system. Our findings highlight important areas of research and design consideration for new digital payment products and services, specifically for central banks contemplating the introduction of a central bank digital currency. We identify barriers that rural populations, Indigenous communities, Canadians with low incomes and persons with disabilities face in using financial products. We also note a deficiency in the current research and payment offerings for those with cognitive accessibility challenges. With these findings, we aim to build awareness of the inequities and challenges present in the current payments system and motivate existing financial technology providers to move toward offering more-inclusive products and services.

A Blueprint for the Fourth Generation of Bank of Canada Projection and Policy Analysis Models

This paper outlines a strategic plan for the development of the fourth generation of Bank of Canada projection and policy analysis models. The plan features a new Canadian workhorse macroeconomic model

as well as a suite of alternative models to better support a risk management approach to monetary policy. This new generation of models seeks to improve our understanding of inflation dynamics, the supply side of the economy and the underlying risks faced by policy-makers coming from uncertainty about how the economy functions. New approaches for dealing with idiosyncratic trends in the data and for leveraging the power of large data sets will be employed.

Variations in Pass-Through from Global Agricultural Commodity Prices to Domestic Food Inflation

This paper examines factors that affect the transmission of fluctuations in global agricultural commodity prices to domestic food inflation. Using panel regressions on data from 53 advanced and emerging-market countries, we investigate how factors such as local crop production conditions, the extent of food industry development and the net agricultural trade status interact with global agricultural prices to affect pass-through to local food prices. Results show that pass-through varies significantly based on these factors. Pass-through decreases during better-than-normal crop conditions, highlighting the importance of local production. Countries with less-developed food industries experience higher pass-through, likely due to the greater importance of raw commodities in diets and less-complex supply chains. Interestingly, net exporters of agricultural commodities exhibit greater pass-through, potentially due to strategic trade adjustments that take advantage of global supply and demand dynamics. These variations in pass-through suggest potential avenues for managing food price inflation in response to shocks to global food prices under different scenarios.

An Overview of the Indigenous Economy in Canada

Attempts to measure aspects of the Indigenous economy in Canada are limited by data availability and quality. Drawing on the most recent data sources and research, we provide an overview of the Indigenous economy in Canada. This includes a discussion of the various characteristics of the Indigenous economy, including the labour market and the business sector, institutional settings, and the state of infrastructure. While several measures suggest economic outcomes have improved for Indigenous Peoples in recent decades, institutional settings and gaps in infrastructure and financing continue to hinder their economic progress. The creation of new institutions is helping Indigenous communities to overcome historic barriers to growth, but continued progress is needed to improve data on the Indigenous economy. This would enable policymakers and

Indigenous leaders to measure progress and make informed decisions.

Estimating the Appropriate Quantity of Settlement Balances in a Floor System

In April 2022, the Bank of Canada announced that it would continue to use a floor system to implement monetary policy by providing a sufficiently large quantity of settlement balances to enable the overnight repo rate to trade at close to the deposit rate. In contrast, the Bank's guiding principles of prudence, transparency and neutrality, which govern the management of its balance sheet, favour maintaining settlement balances as low as possible. In this context, this paper describes two complementary approaches to estimating the appropriate quantity of settlement balances needed to effectively maintain a floor system. The first is a regressionbased analysis to estimate the quantity required to maintain the overnight repo rate close to the Bank's policy interest rate (which is equal to the deposit rate in a floor system). The second is an analysis of operational considerations in implementing a floor system in Canada. Both approaches highlight that considerable uncertainty exists in determining the demand for settlement balances. Such uncertainty emphasizes the need for the Bank to monitor money market conditions as it continues to normalize its balance sheet after undertaking quantitative easing operations related to the COVID-19 pandemic

Digitalization: Prices of Goods and Services

This paper outlines and assesses the various channels through which digitalization can affect prices of goods and services.

How Far Do Canadians Need to Travel to Access Cash?

This paper develops a travel-based metric to measure Canadians' access to cash from automated banking machines (ABMs) and financial institution branches. Our findings indicate that the average distance Canadians need to travel to reach the nearest ABM is 2.0 km, while the average distance to the nearest branch is 4.5 km. Moreover, more than 90% of Canadians live within 5 km of an ABM, and 84% live within 5 km of a branch. The total number of ABMs in Canada increased by 3.7% between 2019 and 2022, and our results show that, overall, access to cash remained stable in that period. However, the total number of branches decreased by 5.2%. The decline in branch coverage is concentrated in rural areas at 7.2%. This may increase the challenge of accessing cash in these regions. Rural Canadians already have less access to cash: they need to drive

an average distance of 4.0 km to the nearest ABM and 9.6 km to the nearest branch, each distance twice the national average.

Making It Real: Bringing Research Models into Central Bank Projections

This paper aims to bridge the gap between models in research and models used to support policy decisions in central banks. Models used in central bank projection environments overlap with research models and benefit from lessons learned in research, but they differ from research models in important ways. For example, to deal with real-world macroeconomic projection issues, central bank models may have a broader scope. To inform policy decision-making, models generally need both a theoretical basis and an ability to "fit" the data. For repeated projection exercises, forecasters need models that can be adapted to deal with data flows, including historical revisions. And, to provide valuable advice, forecasters must incorporate judgement into their projections to address issues outside the scope of the model. If all these challenges are met, then central bank models and projections will also inform the economic narrative that helps the public understand the policy decisions. In this context, this paper is organized around four main themes: 1) model requirements for central bank purposes; 2) overview of the Bank of Canada's main policy models—ToTEM and LENS; 3) challenges in meeting those modelling requirements; and 4) practical approaches to addressing some challenges under time constraints. The paper concludes with a description of how lessons learned from research and practice set the stage for the Bank's future modelling agenda, as discussed in Coletti (2023).

Central Bank Crisis Interventions: A Review of Recent Literature on Potential Costs

Central banks may engage in large-scale lending and asset purchases to stabilize financial markets and implement monetary policy during crises. The ability of these actions to restore financial market functioning is well documented; however, they come with costs. We provide a literature review of the costs associated with these central bank actions, without commenting on the net benefits they provide. We find support for the premise that crisis actions may negatively impact market liquidity, distort asset prices, create conflicts between monetary and financial stability objectives and increase rent seeking and unproductive uses of the liquidity provided by the central bank. We discuss measures that may mitigate the negative impacts of crisis actions.

Supporting the Transition to Net-Zero Emissions: The Evolving Role of Central Banks

While climate change was largely tackled by government policies in the past, central banks are increasingly grappling with the risks climate change poses. They are evaluating their operational policies to reflect these risks and the transition to a net-zero economy. This paper explores the trade-offs and considerations central banks face.

Understanding the Systemic Implications of Climate Transition Risk: Applying a Framework Using Canadian Financial System Data

Our study aims to gain insight on financial stability and climate transition risk. We develop a methodological framework that captures the direct effects of a stressful climate transition shock as well as the indirect—or systemic—implications of these direct effects. We apply this framework using data from the Canadian financial system. To capture the direct effects, we leverage the climate transition scenarios and financial risk assessment methods developed for the Bank of Canada and the Office of the Superintendent of Financial Institutions climate scenario analysis pilot project. We examine the direct effects—in the form of credit, market and liquidity risks—of the climate transition shock on financial system entities within the scope of our study. Specifically, we look at the public and private assets and derivatives portfolios of deposit-taking institutions, life insurance companies, pension funds and investment funds. To assess the indirect effects from the potential spread of the climate transition shock across an interconnected financial system, we extend an agent-based model to explore shock transmission channels such as cross-holding positions, business similarities, common exposures and fire sales. This model considers behavioural assumptions and rules, allowing us to understand the interconnectedness of the financial system. This work strengthens our understanding of how distinct entities within the financial system could be impacted by and respond to climate transition risks and opportunities, and of the potential channels through which those risks and opportunities may spread. More generally, this work contributes to building standardized systemic risk assessment and monitoring tools.

Climate-Related Flood Risk to Residential Lending Portfolios in Canada

We assess the potential financial risks of current and projected flooding caused by extreme weather events in Canada. We focus on the residential real estate secured lending (RESL) portfolios of Canadian financial institutions (FIs) because RESL portfolios are an

important component of FIs' balance sheets and because the assets used to secure such loans are immobile and susceptible to climate-related extreme weather events. We build a loan-level dataset from the residential RESL portfolios of some federally and provincially regulated FIs. We use current and projected flood events under different climate scenarios to apply shocks to these portfolios. We then control for private flood insurance using data from a variety of property and casualty insurers based in Canada. We find that the direct damages of flooding have modest impacts on the FIs' loss given default on their residential RESL portfolios. This is partly due to rising homeowner equity and the recent rapid increase in house prices across Canada. Nevertheless, some risk channels have emerged. Notably, the combined influence of high household leverage and lending in flood zones can exacerbate the risk that lenders face from extreme weather events. Our analysis also shows that other disaster-related risk channels may increase risk to lenders. These channels include climate change, price adjustment of the salvage value and time to settlement. However, this analysis has several limitations. Specifically, the lack of granular flood data may have led to an underestimation and smoothing of financial risks across households. As a result, the analysis potentially smoothed what could be more acute shocks to specific properties.

Procyclicality in Central Counterparty Margin Models: A Conceptual Tool Kit and the Key Parameters

Central counterparty (CCP) initial margin models are procyclical by nature, and CCPs use anti-procyclicality (APC) tools to mitigate this. However, despite the widespread use of such tools, margin models of CCPs around the world reacted severely to the heightened volatility during the March 2020 market turmoil. This triggered a debate globally on the adequacy of APC tools. We offer potential explanations for why those tools were not sufficient. We highlight that, to effectively mitigate procyclicality, the focus should be on the key parameters for both the margin model and the APC tools. One widely adopted APC tool established by the European Market Infrastructure Regulation is the stress period. We show that, to mitigate procyclicality with this tool, the main focus should not be on the calibration of its stressed margin level, but rather on the weight used to add this to the margin model. Further, the stress period tool can be highly effective, but only when its weight parameter is calibrated adequately high. These insights are essential for regulators to provide effective guidance on margin procyclicality, and for CCPs to appropriately design and calibrate their margin systems and procyclicality frameworks. To further serve these needs, we provide a

novel conceptual tool kit for regulators and CCPs. The tool kit allows them to see a margin system's performance in procyclicality as well as in other competing objectives—such as margin coverage and cost of collateral—all in one place and for any combination of calibrations of the key procyclicality parameters. This feature lets regulators set outcomes-based procyclicality targets achievable by CCP margin models and APC tools. Moreover, it helps regulators design prescriptive procyclicality guidance in line with these desired outcomes-based targets. CCPs can use the tool kit to determine the set of parameter calibrations that satisfy the required procyclicality targets and perform sufficiently well in the other competing objectives.

UPCOMING EVENTS

University Recruitment.