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Bank of Canada Quarterly Research Update

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This monthly 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.

PUBLISHED PAPERS

In-Press

Jasmina Arifovic & **Cars Hommes** & Anita Kopányi-Peuker & Isabelle Salle, "Ten Isn't Large! Group Size and Coordination in a Large-Scale Experiment", *American Economic Journal: Microeconomics*, Vol. 15(1): 580-617, February 2023

Marco Bonomo & Carlos Carvalho & **Oleksiy Kryvtsov** & Sigal Ribon & Rodolfo Rigato, "Multi-Product Pricing: Theory and Evidence from Large Retailers", *The Economic Journal*, Vol. 133(651): 905-927, April 2023

Jin Cao & Valeriya Dinger & Tomás Gómez & Zuzana Gric & Martin Hodula & Alejandro Jara & Ragnar Juelsrud & Karolis Liaudinskas & Simona Malovaná & **Yaz Terajima**, "Monetary policy spillover to small open economies: Is the transmission different under low interest rates?", *Journal of Financial Stability*, Vol. 65, April 2023

Tony Chernis & Patrick J. Coe & Shaun P. Vahey, "Reassessing the dependence between economic growth and financial conditions since 1973", *Journal of Applied Econometrics*, Vol. 38(2): 260-267, March 2023

Bruno Feunou & **Jean-Sebastian Fontaine**, "Secular Economic Changes and Bond Yields", *Review of Economics and Statistics*, Vol. 105(2): 408-424, March 2023

Anson T.Y. Ho & **Kim P. Huynh** & David T. Jacho-Chávez & **Geneviève Vallée**, "We didn't start the fire: Effects of a natural disaster on consumers' financial distress", *Journal of Environmental Economics and Management*, Vol. 119, May 2023

Xuan Leng & **Heng Chen** & Wendun Wang, "Multi-dimensional latent group structures with heterogeneous distributions", *Journal of Econometrics*, Vol. 233(1): 1-21, March 2023

Jiaqi Li, "Predicting the demand for central bank digital currency: A structural analysis with survey data", *Journal of Monetary Economics,* Vol. 134: 73-85, March 2023

Jacek Rothert & **Jacob Short**, "Non-traded goods, factor market frictions, and international capital flows", *Review of Economic Dynamics*, Vol. 48: 158-177, April 2023

Forthcoming

Sushant Acharya & Edouard Challe & Keshav Dogra, "Optimal Monetary Policy According to HANK", *American Economic Review*

Jason Allen & Robert Clark & Brent R. Hickman & Eric Richert, "Resolving Failed Banks: Uncertainty, Multiple Bidding and Auction Design", *Review of Economic Studies*

Jason Allen & Milena Wittwer, "Centralizing Over-the-Counter Markets", *Journal of Political Economy*

Jasmina Arifovic & John Duffy & **Janet Hua Jiang**, "Adoption of a new payment method: Experimental evidence", *European Economic Review*

Daniela Balutel & **Marie-Hélène Felt** & **Gradon Nicholls** & Marcel C. Voia, "Bitcoin Awareness, Ownership and Use: 2016-20", *Applied Economics*

Christoph Carnehl & **André Stenzel** & Peter Schmidt, "Pricing for the Stars: Dynamic Pricing in the Presence of Rating Systems", *Management Science*

Carola Conces Binder & **Rodrigo Sekkel**, "Central bank forecasting: A survey", *Journal of Economic Surveys*

Yunjong Eo & **Luis Uzeda** & Benjamin Wong, "Understanding trend inflation through the lens of the goods and services sectors", *Journal of Applied Econometrics*

Benedikt Franke & Qi Gao & **André Stenzel**, "The (Limited) Power of Blockchain Networks for Information Provision", *Management Science*

Anneke Kosse & **Zhentong Lu**, "Transmission of Cyber Risk Through the Canadian Wholesale Payments System", *Journal of Financial Market Infrastructure*

Christopher S. Sutherland, "Forward guidance and expectation formation: A narrative approach", *Journal of Applied Econometrics*

STAFF WORKING PAPERS

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Santiago Carbo-Valverde & Héctor Pérez Saiz & **Hongyu Xiao**, "Geographical and Cultural Proximity in Retail Banking", Bank of Canada Staff Working Paper 2023-2

Yuteng Cheng, "Mandatory Retention Rules and Bank Risk", Bank of Canada Staff Working Paper 2023-3

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Paul Beaudry & **Katya Kartashova** & **Césaire Meh**, "Gazing at r-star: A Hysteresis Perspective", Bank of Canada Staff Working Paper 2023-5

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Kristin Forbes & **Christian Friedrich** & Dennis Reinhardt, "Stress Relief? Funding Structures and Resilience to the Covid Shock", Bank of Canada Staff Working Paper 2023-7

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Kim Huynh & Robert Petrunia & Joel Rodrigue & **Walter Steingress**, "Exporting and Investment Under Credit Constraints", Bank of Canada Staff Working Paper 2023-10

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Aubhik Khan & **Soyoung Lee**, "Persistent Debt and Business Cycles in an Economy with Production Heterogeneity", Bank of Canada Staff Working Paper 2023-17

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Angelika Welte & **Joy Wu**, "The 2021–22 Merchant Acceptance Survey Pilot Study", Bank of Canada Staff Discussion Paper 2023-1

Monica Jain & Walter Muiruri & **Jonathan Witmer** & **Sharon Kozicki** & **Jeremy Harrison**, "Summaries of Central Bank Policy Deliberations: A Canadian Context", Bank of Canada Staff Discussion Paper 2023-2

Oleksiy Kryvtsov & **James C. MacGee** & **Luis Uzeda**, "The 2021–22 Surge in Inflation", Bank of Canada Staff Discussion Paper 2023-3

James Chapman & **Jonathan Chiu** & **Mohammad Davoodalhosseini** & **Janet Hua Jiang** & **Francisco Rivadeneyra** & **Yu Zhu**, "Central Bank Digital Currencies and Banking: Literature Review and New Questions", Bank of Canada Staff Discussion Paper 2023-4

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Grahame Johnson, "A Review of the Bank of Canada's Market Operations related to COVID-19", Bank of Canada Staff Discussion Paper 2023-6

Sarah Miller & **Patrick Sabourin**, "What consistent responses on future inflation by consumers can reveal", Bank of Canada Staff Discussion Paper 2023-7

Lin Chen & **Stephanie Houle**, "Turning Words into Numbers: Measuring News Media Coverage of Shortages", Bank of Canada Staff Discussion Paper 2023-8

ABSTRACTS

In-Press Published Papers

Ten Isn't Large! Group Size and Coordination in a Large-Scale Experiment

We provide experimental evidence on coordination within large groups that could proxy the atomistic nature of real-world markets. We use a bank run game where the two pure-strategy equilibria can be ranked by payoff and risk dominance and a sequence of public announcements introduces stochastic sunspot equilibria. We find systematic group size effects that theory fails to predict. When the payoff-dominant strategy is risky enough, the behavior of small groups is uninformative of the behavior in large groups: unlike smaller groups of size ten, larger groups exclusively coordinate on the Pareto-inferior strategy and never coordinate on sunspots.

Multi-Product Pricing: Theory and Evidence from Large Retailers

We study a unique dataset with comprehensive coverage of daily prices in large multi-product retailers in Israel. Retail stores synchronise price changes around occasional 'peak' days when they reprice around 10% of their products. To assess aggregate implications of partial price synchronisation, we develop a new model in which multi-product firms face economies of scope in price adjustment, and synchronisation is endogenous. Synchronisation of price changes attenuates the average price response to monetary shocks, but only high degrees of synchronisation can substantially strengthen the real effects of monetary policy shocks. Our calibrated model generates real effects similar in magnitude to those in M. Golosov, and R.E. Lucas, Journal of Political Economy (2007), vol. 115, pp. 171–99.

Monetary policy spillover to small open economies: Is the transmission different under low interest rates?

We explore the impact of low and negative monetary policy rates in core world economies on bank lending in four small open economies – Canada, Chile, the Czech Republic and Norway – using confidential bank-level data. We show that the impact on lending in these small open economies depends on the interest rate level in the core. During normal times, monetary policy cuts in the core can reduce credit

supply in small open economies. In contrast, when interest rates in the core are low, further expansionary monetary policy increases lending in small open economies, consistent with an international bank lending channel. These results have important policy implications, suggesting that central banks in small open economies should watch for the impact of potential regime switches in core economies' monetary policy when rates shift to and from the very low end of the distribution.

Reassessing the dependence between economic growth and financial conditions since 1973

Adrian, Boyarchenko and Giannone ((2019), ABG) adapt quantile regression (QR) methods to examine the relationship between US economic growth and financial conditions. We confirm their empirical findings, using their methodology and their pre-2016 sample. Mindful of the importance of the Covid-19 pandemic, we extend the sample to 2021Q3 and find attenuation of the key estimated coefficients using ABG's empirical methods. Given the pandemic observations, we provide robust QR analysis of dependence based on ranked data and explain the relationship with extant copula modelling methods.

Secular Economic Changes and Bond Yields

We build a model of bond yields in an economy with secular changes to inflation, real rate, and output growth. Long-run restrictions identify nominal shocks that do not influence the long-run real rate and output growth. Before the anchoring of inflation around the mid-1990s, nominal shocks lifted the output gap and inflation. This led to a higher and steeper yield curve because the short rate was expected to peak after several quarters, following declines in the responses of growth and inflation. With inflation anchored, nominal shocks have small impacts on inflation, output, and bond yields, mostly via the term premium.

We didn't start the fire: Effects of a natural disaster on consumers' financial distress

Global climate change is increasing the frequency and severity of natural disasters. We use detailed consumer credit data to investigate the impact of the 2016 Fort McMurray Wildfire, the costliest wildfire disaster in Canadian history, on consumers' financial stress. We focus on the arrears of insured mortgages because of their important implications for financial institutions and insurers' business risk and relevant management practices. Our findings suggest that wildfires

have caused more mortgage arrears in severely damaged areas, with both economic and statistical significance. For other areas with relatively minor damage, the increase in arrears is small and statistically insignificant.

Multi-dimensional latent group structures with heterogeneous distributions

This paper aims to identify the multi-dimensional latent grouped heterogeneity of distributional effects. We consider a panel quantile regression model with additive cross-section and time fixed effects. The cross-section effects and quantile slope coefficients are both characterized by grouped patterns of heterogeneity, but each unit can belong to different groups for cross-section effects and slopes. We propose a composite-quantile approach to jointly estimate multi-dimensional group memberships, slope coefficients, and fixed effects. We show that using multiple quantiles improves clustering accuracy if memberships are quantile-invariant. We apply the methods to examine the relationship between managerial incentives and risk-taking behavior.

Predicting the demand for central bank digital currency: A structural analysis with survey data

What would be the potential demand for central bank digital currency (CBDC)? Which design attributes would affect the demand for CBDC? By applying a structural model to a unique Canadian survey dataset, I find that the aggregate CBDC holdings as a percentage of the total household liquid assets could range from 4–52%, based on households' demand perspective. Allowing banks to respond to CBDC would substantially constrain the take-up of CBDC, reducing the upper bound prediction to below 20%. Important design attributes of CBDC identified are budgeting usefulness, anonymity, bundling of bank services, and rate of return.

Non-traded goods, factor market frictions, and international capital flows

The canonical one-sector model over predicts international capital flows by a factor of ten. We show that introducing a non-traded goods sector can reconcile the differences between the theoretical predictions and the observed flows. We analyze the quantitative impact of the non-traded sector using a calibrated model of a small open economy, in which non-traded goods are used in consumption and investment, and need capital and labor to be produced. The

model features international frictions directly affecting international borrowing and lending, as well as domestic frictions that limit the scope of inter-sectoral reallocation of capital and labor. We find that: (1) the impact of domestic frictions on the size of international capital flows is similar to the impact of international frictions, and (2) the median elasticity of capital flows with respect to international frictions in the two-sector model with costly inter-sectoral reallocation is about 50-60% lower than that same elasticity in the one-sector model.

Forthcoming Published Papers

Optimal Monetary Policy According to HANK

We study optimal monetary policy in an analytically tractable Heterogeneous Agent New Keynesian model with rich cross-sectional heterogeneity. Optimal policy differs from a Representative Agent benchmark because monetary policy can affect consumption inequality, by stabilizing consumption risk arising from both idiosyncratic shocks and unequal exposures to aggregate shocks. The tradeoff between consumption inequality, productive efficiency and price stability is summarized in a simple linear-quadratic problem yielding interpretable target criteria. Stabilizing consumption inequality requires putting some weight on stabilizing the level of output, and correspondingly reducing the weights on the output gap and price level relative to the representative agent benchmark.

Resolving Failed Banks: Uncertainty, Multiple Bidding and Auction Design

The FDIC resolves insolvent banks using a scoring auction. Although the basic structure of the scoring rule is known to bidders, they are uncertain about how the FDIC makes trade-offs between the different components. Uncertainty over the scoring rule motivates bidders to submit multiple bids for the same failed bank. To evaluate the effects of uncertainty and multiple bidding for FDIC costs we develop a methodology for analyzing multidimensional bidding environments where the auctioneer's scoring weights are unknown to bidders, ex-ante. We estimate private valuations for banks that failed during the great financial crisis and compute counter-factual experiments in which scoring uncertainty is eliminated. Our findings imply a substantial within-sample reduction in FDIC resolution costs of between 29.8% ($8.2 billion) and 44.6% ($12.3 billion). These savings can reduce policy-driven banking sector distortions, since FDIC resolution costs must be covered either through special levies on banks or through loans from the US Treasury.

Centralizing Over-the-Counter Markets

In traditional over-the-counter markets, investors trade bilaterally through intermediaries, called dealers. We assess whether and how to shift trades onto a centralized platform with trade-level data on the Canadian government bond market. After documenting dealer markups, we specify a model to quantify price and welfare effects from market centralization. We find that, even if they could, not all investors would use the platform: it is costly, dealer competition is low and investors value their dealer relationships. Due to market power and investor-dealer relationships centralization may lower welfare. Enhancing competition increases welfare by up to 12%.

Adoption of a new payment method: Experimental evidence

We develop a framework for studying the introduction of a new payment method in a controlled laboratory environment, where consumers (buyers) and merchants (sellers) can learn to coordinate their adoption decisions over time. The underlying game exhibits network adoption effects as emphasized by the theoretical literature. We elicit players' beliefs about the adoption decisions of the other side of the market so that we can directly test for network effects. We investigate how the additional fixed cost of adopting the new payment method, relative to its savings on per transaction costs, affects merchant's decisions to adopt the new payment method and how that in turn affects buyer's adoption decisions. We find that a low fixed cost favors quick adoption of the new payment method by all participants, while for a sufficiently high fixed cost, merchants gradually learn to reject the new payment method. We also find strong evidence of network effects and that the fixed costs are important for the strong response of seller acceptance decisions to buyer adoption decisions. An evolutionary learning model provides a good characterization of the dynamic adjustment paths found in our experimental data.

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 (Henry et al. 2018, 2019a, 2019b). 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.

Pricing for the Stars: Dynamic Pricing in the Presence of Rating Systems

Maintaining good ratings increases the profits of sellers on online platforms. We analyze the role of strategic pricing for ratings management in a setting where a monopolist sells a good of unknown quality. Higher prices reduce the value for money, which on average worsens reviews. However, higher prices also induce only those consumers with a strong taste for the product to purchase, which on average improves reviews. Our model flexibly parametrizes the two effects. This parametrization can rationalize the observed heterogeneity in the relationship between reviews and prices. Based on an analytic characterization of the optimal dynamic pricing strategy, we study a platform’s choice of the sensitivity of its rating system to incoming reviews. The optimal sensitivity depends on the effect of prices on reviews and on how the platform weighs consumers and sellers in its objective. While sellers always benefit from more sensitivity, consumers may suffer from higher prices and from slower learning from reviews due to endogenously emerging price and rating cycles.

Central bank forecasting: A survey

Central banks' forecasts are important monetary policy inputs and tools for central bank communication. We survey the literature on forecasting at the Federal Reserve, European Central Bank, Bank of England, and Bank of Canada, focusing especially on recent developments. After describing these central banks' forecasting frameworks, we discuss the literature on central bank forecast evaluation and new tests of unbiasedness and efficiency. We also discuss evidence of central banks' informational advantage over private sector forecasters, which appears to have weakened over time, and how central bank forecasts may affect private sector

expectations even in the absence of an informational advantage. We discuss how the Great Recession led central banks to evaluate their forecasting frameworks, how the Covid-19 pandemic has further challenged central bank forecasting, and directions for future research.

Understanding trend inflation through the lens of the goods and services sectors

We distinguish between the goods and services sectors in an unobserved components model of U.S. inflation. We find that prior to the early 1990s, both sectors contributed to volatility of aggregate trend inflation, while since then, this has been predominantly driven by the services sector, with the trend in goods inflation being essentially flat. We document that the large reduction in the volatility of the trend for goods inflation has been the most important driver of the decline in the volatility in aggregate trend inflation reported by Stock and Watson (2007). Our results appear robust to COVID-19 inflation developments.

The (Limited) Power of Blockchain Networks for Information Provision

We investigate the potential and limits of privacy-preserving corporate blockchain applications for information provision. We provide a theoretical model in which heterogeneous firms choose between adopting a blockchain application or relying on traditional third-party intermediaries to inform the capital market. The blockchain's ability to generate information depends on each firm's data profile and all firms' endogenous adoption decisions. We show that blockchain technology can improve the information environment and outperform traditional institutions, with firms' adoption decisions serving as a credible value signal and the application uncovering firm values by analyzing all participating firms' data. However, we also characterize an adverse mixed-adoption equilibrium in which neither of the two channels realizes its full potential and information provision declines not only for individual firms but also in aggregate. The equilibrium is a warning sign that has broad implications for policymakers' regulatory effort and investors' assessment of corporate blockchain applications.

Transmission of Cyber Risk Through the Canadian Wholesale Payments System

In this paper, we study how the impact of a cyber-attack that paralyzes one or multiple banks' ability to send payments would

transmit to other banks through the Canadian wholesale payments system. Based on historical payment data, we simulate a wide range of scenarios and evaluate the total payment disruption in the system. We find that depending on the type and number of banks under attack, the time of the attack and the design of the payments system, attack can in some cases quickly become systemic and result in a significant loss of liquidity in the system. For instance, a three-hour attack on one bank can in a worst case scenario impair the payments capacity of seven other banks within less than an hour and eventually disrupt 25% of the daily payments value. We also demonstrate that the system-wide impact of an attack can be significantly reduced by contingency plans that enable attacked banks to still send high-value payments. Given the interconnectedness of banks, we conclude that the cyber-resilience of a wholesale payment system strongly depends on the cyber-resilience of its participants and underline the importance of strong sectoral collaboration and coordination.

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.

Staff Working Papers

Simulating Intraday Transactions in the Canadian Retail Batch System

This paper proposes a unique approach to simulate intraday transactions in the Canadian retail payments batch system. Such transactions are currently unobtainable. The simulation procedure, though demonstrated in the realm of payments systems, has tremendous potential for helping with data-deficient problems where only high-level aggregate information is available. The approach uses the concept of integer composition in combinatorics to break down the daily total value and volume (available) into individual data points

(unavailable) throughout the day. The algorithm also introduces a technique to incorporate any intraday timing pattern (known or hypothetical) to make simulated data closer to reality. Simulation results show that the probability distribution of individual payment values is remarkably stable through repeated random sampling. This suggests a high degree of accuracy and viability of this simulation method. In addition, the densities of simulated intraday transactions are found to be invariably skewed to the left of the mean payment value, which reflects the nature of retail payments systems.

Geographical and Cultural Proximity in Retail Banking

This paper measures how both geographical and cultural proximity of bank branches affect household credit choice and pricing. We examine both types of proximity jointly to separately identify the importance of soft information versus alternative mechanisms. Using a detailed household-level database for Canada, we find that both geographical and cultural proximity increase consumer credit by reducing the cost of obtaining soft information. Furthermore, soft information obtained via the two types of proximity can be either substitutes for or complements to each other, with complementarity being more likely for products that require high levels of ex-ante screening. Overall, our results suggest that ongoing branch consolidation, happening in many countries, may lead to lower financial inclusion, especially in culturally diverse neighbourhoods.

Mandatory Retention Rules and Bank Risk

This paper studies, theoretically and empirically, the unintended consequences of mandatory retention rules in securitization. The Dodd-Frank Act and the EU Securitisation Regulation both impose a 5% mandatory retention requirement to motivate screening and monitoring. I first propose a novel model showing that while retention strengthens monitoring, it may also encourage banks to shift risk. I then provide empirical evidence supporting this unintended consequence: in the US data, banks shifted toward riskier portfolios after the implementation of the retention rules embedded in Dodd-Frank. Furthermore, the model offers clear, testable predictions about policy and corresponding consequences. In the US data, stricter retention rules caused banks to monitor and shift risk simultaneously. According to the model prediction, such a simultaneous increase occurs only when the retention level is above optimal, which suggests that the current rate of 5% in the US is too high.

Macroeconomic Disasters and Consumption Smoothing: International Evidence from Historical Data

This paper uses a large historical dataset (1870–2016) for 16 industrial economies to show that during macroeconomic disasters (e.g., wars, pandemics, depressions) aggregate consumption and income are significantly less decoupled than during normal times. That is, during these times of turmoil, the consumer intertemporal budget constraint holds more strictly, implying a structural reduction in consumption smoothing. While we also observe this for the ongoing COVID-19 pandemic, this is not the case for more conventional post-war recessions. Our results are obtained using a predictive regression approach that follows directly from the forwardlooking nature of consumption theory. Using a savers-spenders type of model, we show that our findings can be interpreted as stemming from an increase in rule-of-thumb consumer behavior during disasters as well as from a stronger precautionary savings motive of optimizing consumers.

Gazing at r-star: A Hysteresis Perspective

Many explanations for the decline in real interest rates over the last 30 years point to the role that population aging or rising income inequality plays in increasing the long-run aggregate demand for assets. Notwithstanding the importance of such factors, the starting point of this paper is to show that the major change driving household asset demand over this period is instead an increased desire—for a given age and income level—to hold assets. We begin by presenting a simple explanation for this pattern that relies on integrating retirement and intertemporal substitution motives in saving decisions. We then show how the interaction of these two saving motives can have profound implications in terms of the shape of asset demands, the possibility of multiple steady state real interest rates, and a potential role for monetary policy to influence the long-run evolution of real rates. The framework highlights how an inflationary episode followed by a strong monetary response, as we are currently witnessing, can have long-term implications for real interest rates.

(Un)Conventional Monetary and Fiscal Policy

We build a tractable New Keynesian model to study four types of monetary and fiscal policy. We find that quantitative easing (QE), lump-sum fiscal transfers, and government spending have the same effects on the aggregate economy when fiscal policy is fully tax financed. Compared with these three policies, conventional monetary

policy is more inflationary for the same amount of stimulus. QE and transfers have redistribution consequences, whereas government spending and conventional monetary policy do not. Ricardian equivalence breaks down: tax-financed fiscal policy is more stimulative than debt-financed policy. Finally, we study optimal policy coordination and find that adjusting two types of policy instruments—the policy rate together with QE or fiscal transfers—can stabilize three targets simultaneously: inflation, the aggregate output gap, and cross-sectional consumption dispersion.

Stress Relief? Funding Structures and Resilience to the Covid Shock

This paper explores whether different funding structures—including the source, instrument, currency, and counterparty location of funding—affected the extent of financial stress experienced in various countries and sectors during the Covid-19 spread in early 2020. We measure financial stress using a new dataset on changes in credit default swap spreads for sovereigns, banks, and corporates. Then we use country-sector and country-sector-time panels to assess if these different funding structures mitigated—or amplified—the impact of this riskoff shock. A higher share of funding from non-bank financial institutions (NBFI) or in US dollars was correlated with significantly greater stress, while a higher share of funding in debt instruments (instead of loans) or cross-border (instead of domestic) did not significantly impact resilience. The results suggest that macroprudential regulations should broaden their current focus to take into account exposures to NBFI and dollar funding, giving less priority to regulations focused on residency (i.e., capital controls). After the sharp increase in financial stress in early 2020, policy responses targeting these structural vulnerabilities (i.e., US$ swap lines and policies focused on NBFIs) were more effective at mitigating stress related to these funding structures than policies supporting banks, even after controlling for macroeconomic policy responses.

Climate Variability and International Trade

This paper quantifies the impact of hurricanes on seaborne international trade to the United States. Using geocoded hurricane data mapped to satellite tracking data for commercial ships, we identify hurricane intersections on sea-trade routes between U.S. and foreign ports. Matching the timing of hurricane-trade route intersections with monthly U.S. port-level trade data, we isolate the unanticipated effects of a hurricane hitting a trade route using two

separate identification schemes: an event study and a local projection. Our estimates imply that a hurricane reduces route-specific monthly U.S. import flows by 5.4% to 16.0%, leading to an aggregate loss of 1.15% to 3.42% of annual U.S. west coast imports for an average storm season. We find no evidence of trade catching up in the months following a hurricane nor any evidence of rerouting to other ports or other transportation modes (e.g., air). Using our estimates in combination with climate scenarios from the Intergovernmental Panel on Climate Change, we quantify a range of costs of future hurricane disruptions that could occur if trade routes remain fixed.

Fiscal Stimulus and Skill Accumulation over the Life Cycle

Using micro data from the U.S. Consumer Expenditure Survey and Current Population Survey, I document that government spending shocks affect individuals differently over the life cycle. Young households increase their consumption after an expansionary shock while prime-age households reduce it, regardless of their level of income or debt. Productivity and wages increase significantly for young workers. To rationalize these findings, I develop a parsimonious New Keynesian life-cycle model where young agents accumulate skills on the job through a learning-by-doing process. An increase in government spending raises hours worked, which enhances skill accumulation, particularly among young workers who face a steep learning curve. The ensuing increase in the relative labor demand for young workers boosts their wages, thus stimulating their consumption.

Exporting and Investment Under Credit Constraints

We examine the relationship between firms' performance and credit constraints affecting export market entry. The existing research assumes that variation in firms' financial conditions identifies credit constraints. A critical assumption is that financial conditions do not affect real outcomes (performance, exporting, or investment). To relax this assumption, we focus on the direct effect of firms' fundamentals and financial conditions on firms' performance. This approach distinguishes between firms that choose not to export because it is unprofitable from firms that do not export because of binding credit constraints. Our empirical specification allows firms' characteristics to enter both the selection into exporting and return from exporting regressions. The leverage response heterogeneity identifies the presence of credit constraints. Using administrative

Canadian firm-level data, our findings show that new exporters (a) increase their productivity, (b) raise their leverage ratio and (c) increase investment. We estimate that 48 percent of Canadian manufacturers face binding credit constraints when deciding whether to enter export markets. Alleviating these constraints would increase aggregate productivity by 0.97–1.04 percentage points.

Inflation, Output, and Welfare in the Laboratory

We develop an experimental framework to investigate the quantity theory of money and the real effects of inflation in an economy where money serves as a medium of exchange. We test the classical view that inflation reduces output and welfare by taxing monetary exchange. Inflation is engineered by constant money growth. We conduct three treatments, where the newly issued money is used to finance government spending, lump-sum transfers, and proportional transfers, respectively. Experimental results largely support theoretical predictions. Higher money growth leads to higher inflation. Output and welfare are significantly lower with government spending, and output is significantly lower with lump-sum transfers, while there are no significant real effects with proportional transfers. A deviation from theory is that the detrimental effect of money growth in our framework depends on the implementation scheme and is stronger with government spending than with lump-sum transfers.

The Role of Intermediaries in Selection Markets: Evidence from Mortgage Lending

We study the role of brokers in selection markets. We find that broker-clients in the Canadian mortgage market are observationally different from branch-clients. They finance larger loans and have more leverage. We build and estimate a model of mortgage demand to disentangle three possible explanations for observed differences in product choice: (i) borrowers have observed preferences for riskier loans, (ii) borrowers have unobserved preferences for riskier loans, (iii) brokers steer borrowers towards riskier products. We find that brokers steer only about 15% of borrowers to mortgages with longer amortization, while borrowers' own unobservable characteristics drive their decisions for greater leverage.

Learning in a Complex World: Insights from an OLG Lab Experiment

This paper brings novel insights into group coordination and price dynamics in complex environments. We implement an overlapping-

generation model in the lab where output dynamics are given by the well-known chaotic quadratic map. This model structure allows us to study previously unexplored parameter regions where perfect-foresight dynamics exhibit chaotic dynamics. This paper highlights three key findings. First, the price converges to the simplest equilibria, namely either the monetary steady state or the two-cycle in all markets. Second, we document a novel and intriguing finding: a non-monotonicity of the behavior when complexity increases. Convergence to the two-cycle occurs for the intermediate parameter range, while the extreme scenarios of both a simple, stable two-cycle and highly nonlinear dynamics (chaos) lead to coordination on the steady state in the lab. All indicators of coordination and convergence significantly exhibit this non-monotonic relationship in the learning-to-forecast experiments. This finding also persists in the learning-to-optimize design. Finally, convergence in the learning-to-optimize experiment is more challenging to achieve: coordination on the two-cycle is never observed, although the two-cycle Pareto dominates the steady state.

On the Fragility of DeFi Lending

We develop a dynamic model of decentralized finance (DeFi) lending that incorporates two/these key features: 1) borrowing and lending are decentralized, anonymous, overcollateralized and backed by the market value of crypto assets where contract terms are pre-specified and rigid; and 2) information friction exists between borrowers and lenders. We identify a price-liquidity feedback: the market outcome in any given period depends on agents' expectations about lending activities in future periods, with higher price expectations leading to more lending and higher prices in that period. Given the rigidity inherent to smart contracts, this feedback leads to multiple self-fulfilling equilibria where DeFi lending and asset prices move with market sentiment. We show that flexible updates of smart contracts can restore equilibrium uniqueness. This finding highlights the difficulty of achieving stability and efficiency in a decentralized environment without a liquidity backstop.

We Didn't Start the Fire: Effects of a Natural Disaster on Consumers' Financial Distress

Global climate change is increasing the frequency and severity of natural disasters. We use detailed consumer credit data to investigate the impact of the 2016 Fort McMurray wildfire, the costliest wildfire disaster in Canadian history, on consumers' financial stress. We

focus on the arrears of insured mortgages because of their important implications for financial institutions and insurers' business risk and relevant management practices. Our findings suggest that wildfires have caused more mortgage arrears in severely damaged areas, with both economic and statistical significance. For other areas with relatively minor damage, the increase in arrears is small and statistically insignificant.

Cost Pass-Through with Capacity Constraints and International Linkages

Commodity markets are linked through international trade but are separated by heterogeneous regulations and input markets. We investigate theoretically and empirically how regional, as opposed to global, cost shocks pass through into global prices. Capacity constraints mitigate the output response to regional cost shocks in the short run. Once constraints bind, the pass-through of a cost increase is enhanced while for cost decreases it drops to zero. We study the market for ammonia, a commodity produced largely from natural gas, to highlight the nonlinearity of the cost pass-through and its implications for unilateral climate policies.

Persistent Debt and Business Cycles in an Economy with Production Heterogeneity

We study an economy with a time-varying distribution of production to examine the role of debt in amplifying and propagating recessions. In our model, entrepreneurs use risky, longterm debt to finance capital. Liquid assets serve as collateral and transaction costs make debt illiquid. Debt payments increase the volatility of earnings relative to output, deterring entrepreneurs with insufficient collateral from financing efficient levels of capital. This results in a misallocation of resources. In a large recession, productive entrepreneurs with high levels of debt deleverage, amplifying the downturn. The model economy exhibits asymmetries over the business cycle. Recessions involve a rapid deterioration of economic activity, while expansions are more gradual. When a recession coincides with a rise in leverage resulting from a fall in assets, fewer producers operate at efficient levels. When the aggregate business leverage is ten percentage points above average, the half-life of the recovery doubles.

Central Bank Forecasting: A Survey

Central banks' forecasts are important monetary policy inputs and tools for central bank communication. We survey the literature on

forecasting at the Federal Reserve, European Central Bank, Bank of England and Bank of Canada, focusing especially on recent developments. After describing these central banks' forecasting frameworks, we discuss the literature on central bank forecast evaluation and new tests of unbiasedness and efficiency. We also discuss evidence of central banks' informational advantage over private sector forecasters—which appears to have weakened over time—and how central bank forecasts may affect private sector expectations even in the absence of an informational advantage. We discuss how the Great Recession led central banks to evaluate their forecasting frameworksand how the COVID-19 pandemic has further challenged central bank forecasting. Finally, we consider directions for future research.

Supply Drivers of US Inflation Since the COVID-19 Pandemic

This paper examines the contribution of several supply factors to US headline inflation since the start of the COVID-19 pandemic. We identify six supply shocks using a structural VAR model: labor supply, labor productivity, global supply chain, oil price, price mark-up and wage mark-up shocks. Our shock identification relies mainly on sign restrictions. But for the global supply chain shock, we propose a new identification scheme combining sign, narrative and variance decomposition restrictions. Historical decomposition results suggest that global supply chain and oil price shocks are the biggest supply contributors to the US inflation during the pandemic. In contrast, labor shortages only mildly contribute to inflation, but their impact on output is larger in that period. Additionally, price and wage mark-up shocks start to significantly contribute to inflation only towards the middle of 2022. Finally, our analysis, which also allows the identification of monetary policy and aggregate demand shocks, suggests that demand and supply factors are almost equally responsible for the movements in the inflation rate during the pandemic.

Staff Discussion Papers

The 2021–22 Merchant Acceptance Survey Pilot Study

In recent years, the rise in digital payment innovations such as contactless cards and Interac e-Transfer has spurred a discussion about the future of cash at the point of sale. The COVID19 pandemic has also contributed to this discussion: While consumers reported that some merchants started to refuse cash early in the pandemic, such reported refusals dropped as the pandemic progressed. The Bank of Canada's most recent Merchant Acceptance Survey (MAS)

took place in 2018, prompting a need for updated data to study merchant cash acceptance, payment trends and conditions for the potential issuance of a central bank digital currency (Lane 2020, 2021a). Against this background, the Bank conducted the 2021–22 MAS Pilot Study to monitor payment methods accepted by small and medium-sized businesses (SMBs). Survey data was collected from merchants in two batches, in late 2021 and early 2022. Our results show that 97% of SMBs in Canada accepted cash in 2021–22 and only 3% have plans to stop accepting cash. For cards and digital payments, merchant acceptance has increased since 2018. Additionally, the acceptance of different payment methods varies by the size of the merchant, industry and region.

Summaries of Central Bank Policy Deliberations: A Canadian Context

This paper provides the context, rationale and key considerations that informed the Bank of Canada's decision to publish a summary of monetary policy deliberations. It includes an analysis of how other central banks disclose minutes and summaries of their monetary policy deliberations. Most other central banks surveyed publish some sort of summary of deliberations. The Bank of Canada's existing communications already include aspects of these summaries. However, the Bank does not normally provide some information that they contain, such as: • a review of the policy choices that were discussed • a diversity of viewpoints on the economic outlook and policy choices • the perspectives of individual members. Publishing a summary of deliberations could enhance transparency, accountability and credibility and also reinforce the Bank's independence. However, these benefits must be balanced against the potential for constraints on internal debate or the sending of mixed messages about the Bank's outlook and decisions. The Bank of Canada Act empowers the Governor to make decisions, but in practice, decisions are made by consensus among members of the Bank's Governing Council. This decision-making by consensus could have implications for what could or should be included in a summary. In the Canadian context, assuming the Bank will provide additional information, we also discuss some advantages and disadvantages of providing a summary of deliberations as a separate communication product or as an enhancement to current communications products. The material in the paper originally served as background information for internal discussions at the Bank of Canada around publishing a summary of policy deliberations. Following those discussions, the International Monetary Fund (IMF) published a review of the Bank of Canada's

transparency, concluding that the Bank "… sets a high benchmark for transparency" (IMF 2022). In that review, the IMF provided a recommendation on how the Bank could further improve its transparency by providing more information on its monetary policy deliberations. In response to the IMF review and internal discussions at the Bank, the Bank has publicly committed to providing a summary of its policy deliberations beginning in February 2023.

The 2021–22 Surge in Inflation

The rise in inflation in 2021–22 sparked a growing literature and debate over the causes of the surge as well as the near- and medium-term path for inflation. This review offers three key messages. First, the exceptional nature of shocks resulting from the COVID-19 pandemic and geopolitical events drove the surge in inflation and the initial underestimation by many central banks of the extent of inflationary pressures. Second, the pandemic may have accelerated structural changes in goods and labour markets, which are likely to put pressure on goods prices and wages in the medium and long term. Third, the resulting shifts in relative prices for goods, services and labour are unlikely to be large enough to threaten a return of inflation to target but may require somewhat higher interest rates than those in the decade before the pandemic.

Central Bank Digital Currencies and Banking: Literature Review and New Questions

We review the nascent but fast-growing literature on central bank digital currencies (CBDCs), focusing on their potential impacts on private banks. We evaluate these impacts in three areas of traditional banking: payments, lending, and liquidity and maturity transformation. For each area, we discuss the lessons learned and identify gaps in the research yet to be fully explored. We also take a broader look at CBDCs and highlight two promising directions for future research. One is to study CBDCs through the lens of industrial organization, exploring issues such as platform competition and business models. The second is the crypto space and its new developments such as stablecoins and decentralized finance.

The Canadian Neutral Rate of Interest through the Lens of an Overlapping-Generations Model

The neutral rate of interest is an important concept and communication tool for central banks. We develop a small open economy model with overlapping generations to study the

determinants of the neutral real rate of interest in a small open economy. The model captures domestic factors such as population aging, declining productivity, rising government debt and inequality. Foreign factors are captured by changes in the global neutral real rate. We use the model to evaluate secular dynamics of the neutral rate in Canada from 1980 to 2018. We find that changes in both foreign and domestic factors resulted in a protracted decline in the neutral rate.

A Review of the Bank of Canada's Market Operations related to COVID-19

The economic lockdowns that began in March 2020 in response to the COVID-19 pandemic led to an unparalleled level of financial market disruption. Investors sought liquidity by selling financial assets and drawing down loans and credit lines. The speed, scale and one-way nature of these transactions caused an almost complete breakdown of market functioning. In response, the Bank of Canada launched 10 extraordinary programs, 9 of which had never been used before, to restore market functioning. As market conditions improved, 9 of the 10 programs were wound down. One, the Government of Canada Bond Purchase Program, was continued and transitioned into a monetary policy tool. In general, most of the programs were well designed and effectively executed—an impressive achievement given the circumstances under which they were conceived, developed and deployed. The extreme level of uncertainty and the magnitude of the downside risks to economic and financial activity warranted an aggressive response. Going forward, however, several areas exist where program design and implementation could be changed if these programs ever need to be used again. Overall, the design and implementation recommendations for future interventions focus on the need to ensure the programs are appropriately structured, in terms of both size and duration, for the financial and economic circumstances. Given the speed with which the outlook can change, program parameters must be flexible, and the Bank must be nimble in making the necessary adjustments.

What consistent responses on future inflation by consumers can reveal

Inflation expectations play a vital role in determining inflation. Central bankers need to understand their intricacies and the information they can reveal. We look at the consistency of consumers' answers to questions on inflation expectations in the Bank of Canada's Canadian

Survey of Consumer Expectations. We analyze factors that may explain consistencies among individuals and overall. We also compare the inflation forecasts of consumers with consistent responses with those of professional forecasters and consumers with varying responses.

Turning Words into Numbers: Measuring News Media Coverage of Shortages

We generate high-frequency and up-to-date indicators to monitor news media coverage of supply (raw, intermediate and final goods) and labour shortages in Canada. We use natural language processing to construct two news-based indicators and time-varying topic narratives to track Canadian media coverage of these shortages from 2000 to 2022. This makes our indicators an insightful alternative monitoring tool for policy. Notably, our indicators track well with monthly price indexes and measures from the Bank of Canada's Business Outlook Survey, and they are highly correlated with commonly tracked indicators of supply constraint. Moreover, the news-based indicators reflect the attention of the public on pressing issues.

UPCOMING EVENTS

Kyle Dempsey (Ohio State University)
Organizer: EFR FMD/FSD Seminar Series
Date: 4 April 2023

Shihan Xie (University of Illinois, Urbana-Champaign)
Organizer: FMD Research Seminar
Date: 12 April 2023

Nicolas Petrosky-Nadeau (Federal Reserve Bank of San Francisco)
Organizer: EFR CEA/INT Seminar Series
Date: 14 April 2023

Joel Rodrigue (Vanderbilt University)
Organizer: EFR Seminar Series
Date: 18 April 2023

Alfred Lehar (University of Calgary, Haskayne School of Business)
Organizer: EFR BAP Visiting Speaker
Date: 18 April 2023

Jonathan Heathcote (Federal Reserve Bank of Minneapolis)
Organizer: EFR CEA/INT Seminar Series
Date: 21 April 2023

Yizhou Jin (University of Toronto, Rotman)
Organizer: EFR BAP Visiting Speaker
Date: 25 April 2023

Carlos Carvalho (Kapitalo Investimentos and PUC-Rio)
Organizer: INT Visiting Speaker
Date: 26 April 2023

Kris Nimark (Cornell University)
Organizer: EFR CEA/INT Visiting Speaker
Date: 28 April 2023